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ABSTRACT

This Unified Sciences and Mathematics for Elementary Schools (USMES) unit challenges students to grow plants and to determine some purpose for their use (transplanting, selling, gifts). The challenge is general enough to apply to many problem-solving situations in mathematics, science, social science, and language arts at any elementary school level (grades 1-8). The Teacher Resource Book for the unit is divided into five sections. Section I describes the USMES approach to student-initiated investigations of real problems, including a discussion of the nature of USMES "challenges." Section II provides an overview of possible student activities with comments on prerequisite skills, instructional strategies, suggestions when using the unit with primary grades, flow charts illustrating how investigations evolve from students' discussions of an advertising problem, and a hypothetical account of intermediate-level class activities. Section III provides documented events of actual class activities from grades 2/3, 5, and 6. Section IV includes lists of "How To" cards and background papers, bibliography of non-USMES materials, and a glossary. Section V consists of charts identifying skills, concepts, processes, and areas of study learned as students become involved with investigations. (JN)

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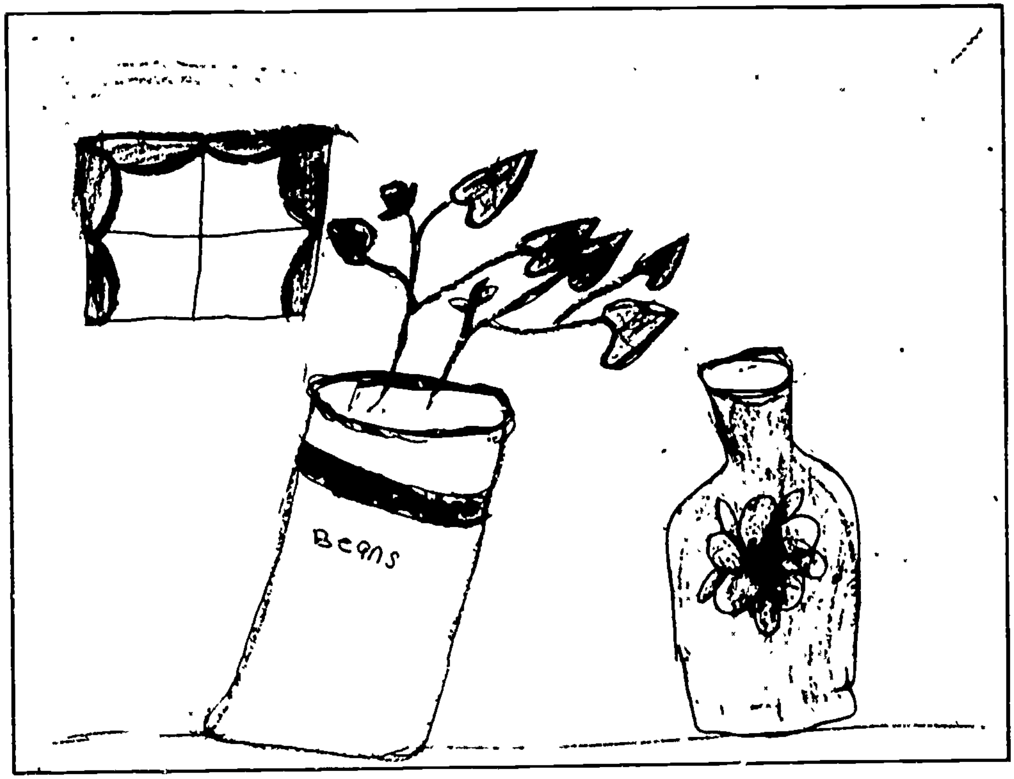
UNIFIED SCIENCES AND MATHEMATICS FOR ELEMENTARY SCHOOLS:
Mathematics and the Natural, Social, and Communications Sciences in Real Problem Solving.



Growing Plants

Second Edition

Education Development Center, Inc.
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Trial Edition

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CHALLENGE: GROW PLANTS FOR __________.
(Children determine the specific purpose, such as for gifts, for transplanting into a garden, for selling, etc.)

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Preface

The USMES Project

Unified Sciences and Mathematics for Elementary Schools: Mathematics and the Natural, Social, and Communications Sciences in Real Problem Solving (USMES) was formed in response to the recommendations of the 1967 Cambridge Conference on the Correlation of Science and Mathematics in the Schools.* Since its inception in 1970, USMES has been funded by the National Science Foundation to develop and carry out field trials of interdisciplinary units centered on long-range investigations of real and practical problems (or "challenges") taken from the local school/community environment. School planners can use these units to design a flexible curriculum for grades kindergarten through eight in which real problem solving plays an important role.

Development and field trials were carried out by teachers and students in the classroom with the assistance of university specialists at workshops and at occasional other meetings. The work was coordinated by a staff at the Education Development Center in Newton, Massachusetts. In addition, the staff at EDC coordinated implementation programs involving schools, districts, and colleges that are carrying out local USMES implementation programs for teachers and schools in their area.

Trial editions of the following units are currently available:

Advertising	Nature Trails
Bicycle Transportation	Orientation
Classroom Design	Pedestrian Crossings
Classroom Management	Play Area Design and Use
Consumer Research	Protecting Property
Describing People	School Rules
Designing for Human Proportions	School Supplies
Design Lab Design	School Zoo
Eating in School	Soft Drink Design
Getting There	Traffic Flow
Growing Plants	Using Free Time
Manufacturing	Ways to Learn/Teach
Mass Communications	Weather Predictions

*See *Goals for the Correlation of Elementary Science and Mathematics*, Houghton Mifflin Co., Boston, 1969.

USMES Resources

In responding to a long-range challenge, the students and teachers often have need of a wide range of resources. In fact, all of the people and materials in the school and community are important resources for USMES activities. In addition USMES provides resources for both teachers and students. A complete set of all the written materials comprise the USMES library, which should be available in each school using USMES units. These materials include--

1. *The USMES Guide*: This book is a compilation of materials that may be used for long-range planning of a curriculum that incorporates the USMES program. It describes the USMES project, real problem solving, classroom strategies, the Design Lab, the units, and the support materials as well as ways that USMES helps students learn basic skills.

2. *Teacher Resource Books* (one for each challenge): Each of these guides to using USMES units describes a broad problem, explains how students might narrow that problem to fit their particular needs, recommends classroom strategies, presents edited logs from teachers whose classes have worked on the unit, and contains charts that indicate basic skills, processes, and areas of study that students may learn and utilize.

3. *Design Lab Manual*: This guide helps teachers and administrators set up, run, and use a Design Lab--a place with tools and materials in which the students can build things they need for their work on USMES. A Design Lab may be a corner of a classroom, a portable cart, or a separate room. Because many "hands-on" activities may take place in the classroom, every USMES teacher should have a Design Lab Manual.

4. *"How To" Series*: These student materials provide information to students about specific problems that may arise during USMES units. The regular *"How To" Series* covers problems in measuring, graphing, data handling, etc., and is available in two versions--a series of

cartoon-style booklets for primary grades and a series of magazine-style booklets with more reading matter for upper grades. The *Design Lab "How To" Series* is available in two illustrated card versions--one for primary grades and one for upper grades. A complete list of the *"How To" Series* can be found in the *USMES Guide*.

5. Background Papers: These papers, correlated with the *"How To" Series*, provide teachers with information and hints that do not appear in the student materials. A complete list can be found in the *USMES Guide*.

6. Curriculum Correlation Guide By correlating the twenty-six USMES units with other curriculum materials, this book helps teachers to integrate USMES with other school activities and lessons.

The preceding materials are described in brief in the USMES brochure, which can be used by teachers and administrators to disseminate information about the program to the local community. A variety of other dissemination and implementation materials are also available for individuals and groups involved in local implementation programs. They include *Preparing People for USMES: An Implementation Resource Book*, the USMES slide/tape show, the Design Lab slide/tape show, the Design Lab brochure, videotapes of classroom activities, a general report on evaluation results, a map showing the locations of schools conducting local implementation of USMES, a list of experienced USMES teachers and university consultants, and newspaper and magazine articles.

* * * * *

Because Tri-Wall was the only readily available brand of three-layered cardboard at the time the project began, USMES has used it at workshops and in schools; consequently, references to Tri-Wall can be found throughout the Teacher Resource Books. The addresses of suppliers of three-layered cardboard can be found in the Design Lab Manual.

Introduction

Using the Teacher Resource Book

When teachers try a new curriculum for the first time, they need to understand the philosophy behind the curriculum. The USMES approach to student-initiated investigations of real problems is outlined in section A of this Teacher Resource Book.

Section B starts with a brief overview of possible student activities arising from the challenge; comments on prerequisite skills are included. Following that is a discussion of the classroom strategy for USMES real problem-solving activities, including introduction of the challenge, student activity, resources, and Design Lab use. Subsequent pages include a description of the use of the unit in primary grades, a flow chart and a composite log that indicate the range of possible student work, and a list of questions that the teacher may find useful for focusing the students' activities on the challenge.

Because students initiate all the activities in response to the challenge and because the work of one class may differ from that undertaken by other classes, teachers familiar with USMES need to read only sections A and B before introducing the challenge to students.

Section C of this book is the documentation section. These edited teachers' logs show the variety of ways in which students in different classes have worked at finding a solution to the challenge.

Section D contains a list of the titles of relevant sets of "How To" Cards and brief descriptions of the Background Papers pertaining to the unit. Also included in section D is a glossary of the terms used in the Teacher Resource Book and an annotated bibliography.

Section E contains charts that indicate the comparative strengths of the unit in terms of real problem solving, mathematics, science, social science, and language arts. It also contains a list of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in the unit. These charts and lists are based on documentation of activities that have taken place in USMES classes. Knowing ahead of time which basic skills and processes are likely to be utilized, teachers can postpone teaching that part of their regular program until later in the year. At that time students can study them in the usual way if they have not already learned them as part of their USMES activities.

A. Real Problem Solving and USMES

*If life were of such a constant nature that there were only a few chores to do and they were done over and over in exactly the same way, the case for knowing how to solve problems would not be so compelling. All one would have to do would be to learn how to do the few jobs at the outset. From then on he could rely on memory and habit. Fortunately--or unfortunately depending upon one's point of view--life is not simple and unchanging. Rather it is changing so rapidly that about all we can predict is that things will be different in the future. In such a world the ability to adjust and to solve one's problems is of paramount importance.**

Real Problem Solving

USMES is based on the beliefs that real problem solving is an important skill to be learned and that many math, science, social science, and language arts skills may be learned more quickly and easily within the context of student investigations of real problems. Real problem solving, as exemplified by USMES, implies a style of education which involves students in investigating and solving real problems. It provides the bridge between the abstractions of the school curriculum and the world of the student. Each USMES unit presents a problem in the form of a challenge that is interesting to children because it is both real and practical. The problem is real in several respects: (1) the problem applies to some aspect of student life in the school or community, (2) a solution is needed and not presently known, at least for the particular case in question, (3) the students must consider the entire situation with all the accompanying variables and complexities, and (4) the problem is such that the work done by the students can lead to some improvement in the situation. This expectation of useful accomplishment provides the motivation for children to carry out the comprehensive investigations needed to find some solution to the challenge.

The level at which the children approach the problems, the investigations that they carry out, and the solutions

*Kenneth B. Henderson and Robert E. Pingry, "Problem-Solving in Mathematics," in *The Learning of Mathematics: Its Theory and Practice*, Twenty-first Yearbook of the National Council of Teachers of Mathematics (Washington, D.C.: The Council, 1953), p. 233.

that they devise may vary according to the age and ability of the children. However, real problem solving involves them, at some level, in all aspects of the problem-solving process: definition of the problem; determination of the important factors in the problem; observation; measurement; collection of data; analysis of the data using graphs, charts, statistics, or whatever means the students can find; discussion; formulation and trial of suggested solutions; clarification of values; decision making; and communications of findings to others. In addition, students become more inquisitive, more cooperative in working with others, more critical in their thinking, more self-reliant, and more interested in helping to improve social conditions.

The USMES Approach

To learn the process of real problem solving, the students must encounter, formulate, and find some solution to complete and realistic problems. The students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of their hypotheses and conclusions. In real problem-solving activities, the teacher acts as a coordinator and collaborator, not an authoritative answer-giver.

The problem is first reworded by students in specific terms that apply to their school or community, and the various aspects of the problem are discussed by the class. The students then suggest approaches to the problem and set priorities for the investigations they plan to carry out. A typical USMES class consists of several groups working on different aspects of the problem. As the groups report periodically to the class on their progress, new directions are identified and new task forces are formed as needed. Thus, work on an USMES challenge provides students with a "discovery-learning" or "action-oriented" experience.

Real problem solving does not rely solely on the discovery-learning concept. In the real world people have access to certain facts and techniques when they recognize the need for them. The same should be true in the classroom. When the students find that certain facts and skills are necessary for continuing their investigation, they learn willingly and quickly in a more directed way to acquire these facts and skills. Consequently, the students should have available different resources that they may use as they recognize the need for them, but they should still be left with a wide scope to explore their own ideas and methods.

Certain information on specific skills is provided by the sets of USMES "How To" Cards. The students are referred only to the set for which they have clearly identified a need and only when they are unable to proceed on their own. Each "How To" Cards title clearly indicates the skill involved--"How to Use a Stopwatch," "How to Make a Bar Graph Picture of Your Data," etc. (A complete list of the "How To" Cards can be found in Chapter IX of the USMES Guide.)

Another resource provided by USMES is the Design Lab or its classroom equivalent. The Design Lab provides a central location for tools and materials where devices may be constructed and tested without appreciably disrupting other classroom activities. Ideally, it is a separate room with space for all necessary supplies and equipment and work space for the children. However, it may be as small as a corner of the classroom and may contain only a few tools and supplies. Since the benefits of real problem solving can be obtained by the students only if they have a means to follow up their ideas, the availability of a Design Lab can be a very important asset.

Optimally, the operation of the school's Design Lab should be such as to make it available to the students whenever they need it. It should be as free as possible from set scheduling or programming. The students use the Design Lab to try out their own ideas and/or to design, construct, test, and improve many devices initiated by their responses to the USMES challenges. While this optimum operation of the Design Lab may not always be possible due to various limitations, "hands-on" activities may take place in the classroom even though a Design Lab may not be available. (A detailed discussion of the Design Lab can be found in Chapter VI of the USMES Guide, while a complete list of "How To" Cards covering such Design Lab skills as sawing, gluing, nailing, soldering, is contained in Chapter IX.)

Work on all USMES challenges is not only sufficiently complex to require the collaboration of the whole class but also diverse enough to enable each student to contribute according to his/her interest and ability. However, it should be noted that if fewer than ten to twelve students from the class are carrying out the investigation of a unit challenge, the extent of their discovery and learning can be expected to be less than if more members of the class are involved. While it is possible for a class to work on two related units at the same time, in many classes the students progress better with just one.

The amount of time spent each week working on an USMES challenge is crucial to a successful resolution of the

problem. Each challenge is designed so that the various investigations will take from thirty to forty-five hours, depending on the age of the children, before some solution to the problem is found and some action is taken on the results of the investigations. Unless sessions are held at least two or three times a week, it is difficult for the children to maintain their interest and momentum and to become involved intensively with the challenge. The length of each session depends upon the age level of the children and the nature of the challenge. For example, children in the primary grades may proceed better by working on the challenge more frequently for shorter periods of time, perhaps fifteen to twenty minutes, while older children may proceed better by working less frequently for much longer periods of time.

Student interest and the overall accomplishments of the class in finding and implementing solutions to the challenge indicate when the class's general participation in unit activities should end. (Premature discontinuance of work on a specific challenge is often due more to waning interest on the part of the teacher than to that of the students.) However, some students may continue work on a voluntary basis on one problem, while the others begin to identify possible approaches to another USMES challenge.

Importance of the Challenge

Although individual (or group) discovery and student initiation of investigations is the process in USMES units, this does not imply the constant encouragement of random activity. Random activity has an important place in children's learning, and opportunities for it should be made available at various times. During USMES activities, however, it is believed that children learn to solve real problems only when their efforts are focused on finding some solution to the real and practical problem presented in the USMES challenge. It has been found that students are motivated to overcome many difficulties and frustrations in their efforts to achieve the goal of effecting some change or at least of providing some useful information to others. Because the children's commitment to finding a solution to the challenge is one of the keys to successful USMES work, it is extremely important that the challenge be introduced so that it is accepted by the class as an important problem to which they are willing to devote a considerable amount of time.

The challenge not only motivates the children by stating the problem but also provides them with a criterion for judging their results. This criterion--if it works, it's right (or if it helps us find an answer to our problem, it's

a good thing to do)--gives the children's ideas and results a meaning within the context of their goal. Many teachers have found this concept to be a valuable strategy that not only allows the teacher to respond positively to all of the children's ideas but also helps the children themselves to judge the value of their efforts.

Role of the Teacher

With all of the above in mind, it can be said that the teacher's responsibility in the USMES strategy for open classroom activities is as follows:

1. Introduce the challenge in a meaningful way that not only allows the children to relate it to their particular situation but also opens up various avenues of approach.

2. Act as a coordinator and collaborator. Assist, not direct, individuals or groups of students as they investigate different aspects of the problem.

3. Hold USMES sessions at least two or three times a week so that the children have a chance to become involved in the challenge and carry out comprehensive investigations.

4. Provide the tools and supplies necessary for initial hands-on work in the classroom or make arrangements for the children to work in the Design Lab.

5. Be patient in letting the children make their own mistakes and find their own way. Offer assistance or point out sources of help for specific information (such as the "How To" Cards) only when the children become frustrated in their approach to the problem. Conduct skill sessions as necessary.

6. Provide frequent opportunities for group reports and student exchanges of ideas in class discussions. In most cases, students will, by their own critical examination of the procedures they have used, improve or set new directions in their investigations.

7. If necessary, ask appropriate questions to stimulate the students' thinking so that they will make more extensive and comprehensive investigations or analyses of their data.

8. Make sure that a sufficient number of students (usually ten to twelve) are working on the challenge so that activities do not become fragmented or stall.

Student success in USMES unit activities is indicated by the progress they make in finding some solution to the challenge, not by following a particular line of investigation nor by obtaining specified results. The teacher's role in the USMES strategy is to provide a classroom atmosphere in which all students can, in their own way, search out some solution to the challenge.

USMES in the Total School Program

Today many leading educators feel that real problem solving (under different names) is an important skill to be learned. In this mode of learning particular emphasis is placed on developing skills to deal with real problems rather than the skills needed to obtain "correct" answers to contrived problems. Because of this and because of the interdisciplinary nature of both the problems and the resultant investigations, USMES is ideal for use as an important part of the elementary school program. Much of the time normally spent in the class on the traditional approaches to math, science, social science, and language arts skills can be safely assigned to USMES activities. In fact, as much as one-fourth to one-third of the total school program might be allotted to work on USMES challenges. Teachers who have worked with USMES for several years have each succeeding year successfully assigned to USMES activities the learning of a greater number of traditional skills. In addition, reports have indicated that students retain for a long time the skills and concepts learned and practiced during USMES activities. Therefore, the time normally spent in reinforcing required skills can be greatly reduced if these skills are learned and practiced in the context of real problem solving.

Because real problem-solving activities cannot possibly cover all the skills and concepts in the major subject areas, other curricula as well as other learning modes (such as "lecture method," "individual study topics," or programmed instruction) need to be used in conjunction with USMES in an optimal education program. However, the other

instruction will be enhanced by the skills, motivation, and understanding provided by real problem solving, and, in some cases, work on an USMES challenge provides the context within which the skills and concepts of the major subject areas find application.

In order for real problem solving taught by USMES to have an optimal value in the school program, class time should be apportioned with reason and forethought, and the sequence of challenges investigated by students during their years in elementary school should involve them in a variety of skills and processes. Because all activities are initiated by students in response to the challenge, it is impossible to state unequivocally which activities will take place. However, it is possible to use the documentation of activities that have taken place in USMES trial classes to schedule instruction on the specific skills and processes required by the school system. Teachers can postpone the traditional way of teaching the skills that might come up in work on an USMES challenge until later in the year. At that time students can learn the required skills in the usual way if they have not already learned them during their USMES activities.

These basic skills, processes, and areas of study are listed in charts and lists contained in each Teacher Resource Book. A teacher can use these charts to decide on an overall allocation of class time between USMES and traditional learning in the major subject disciplines. Examples of individual skills and processes are also given so that the teacher can see beforehand which skills a student may encounter during the course of his investigations. These charts and lists may be found in section E.

Ways In Which USMES Differs From Other Curricula

As the foregoing indicates, USMES differs significantly from other curricula. Real problem solving develops the problem-solving ability of students and does it in a way (learning-by-doing) that leads to a full understanding of the process. Because of the following differences, some teacher preparation is necessary. Some teachers may have been introduced by other projects to several of the following new developments in education, but few teachers have integrated all of them into the new style of teaching and learning that real problem solving involves.

1. New Area of Learning--Real problem solving is a new area of learning, not just a new approach or a new content within an already-defined subject area. Although many subject-matter curricula

include something called problem solving, much of this problem solving involves contrived problems or fragments of a whole situation and does not require the cognitive skills needed for the investigation of real and practical problems. Learning the cognitive strategy required for real problem solving is different from other kinds of learning.

3. Interdisciplinary Education--Real problem solving integrates the disciplines in a natural way; there is no need to impose a multi-disciplinary structure. Solving real and practical problems requires the application of skills, concepts, and processes from many disciplines. The number and range of disciplines are unrestricted and the importance of each is demonstrated in working toward the solution of practical problems.

3. Student Planning--To learn the process of problem solving, the students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of the hypotheses and conclusions. In real problem-solving activities the teacher acts as a coordinator and collaborator, not as an authoritative source of answers.

4. Learning-by-Doing--Learning-by-doing, or discovery learning as it is sometimes called, comes about naturally in real problem solving since the problems tackled by each class have unique aspects; for example, different lunchrooms or pedestrian crossings have different problems associated with them and, consequently, unique solutions. The challenge, as defined in each situation, provides the focus for the children's hands-on learning experiences, such as collecting real data; constructing measuring instruments, scale models, test equipment, etc.; trying their suggested improvements; and (in some units) preparing reports and presentations of their findings for the proper authorities.

5. Learning Skills and Concepts as Needed--Skills and concepts are learned in real problem solving

as the need for them arises in the context of the work being done, rather than having a situation imposed by the teacher or the textbook being used. Teachers may direct this learning when the need for it arises, or students may search out information themselves from resources provided.

6. Group Work--Progress toward a solution to a real problem usually requires the efforts of groups of students, not just individual students working alone. Although some work may be done individually, the total group effort provides good opportunities for division of labor and exchange of ideas among the groups and individuals. The grouping is flexible and changes in order to meet the needs of the different stages of investigation.

7. Student Choice--Real problem solving offers classes the opportunity to work on problems that are real to them, not just to the adults who prepare the curriculum. In addition, students may choose to investigate particular aspects of the problem according to their interest. The variety of activities ensuing from the challenge allows each student to make some contribution towards the solution of the problem according to his or her ability and to learn specific skills at a time when he or she is ready for that particular intellectual structure.

B. General Papers on Growing Plants

1. OVERVIEW OF ACTIVITIES

Challenge:

Grow plants for __________. (Children determine the specific purpose, such as for gifts, for transplanting into a garden, for selling, etc.)

Possible Class Challenges:

Grow plants to make the room or school area more attractive.

Grow plants for sale or display at a school fair or carnival.

Grow plants to feed animals for the School Zoo unit.

Grow plants and have them bloom by Mother's Day.

Children of all ages are excited about "helping" green plants grow and will be enthusiastic about the idea of growing plants for a specific purpose. The challenge for this unit is left open to suit the interests of the students; however, the purpose should be clearly identified so that the children are solving a problem rather than studying the growth of plants. In some classes, students may want to grow their own plants to give to parents or to a sick friend. Other classes may decide to grow plants for a school fair, to raise money for a class trip, to make the room or school more attractive, to feed the guinea pigs, etc.

The Growing Plants challenge may be introduced to the class during a discussion on the need to raise plants for a specific purpose. Class discussion may be initiated after the teacher or a student has brought in some plants to show the class. The challenge may also arise during work on another USMES unit; for example, during work on the School Zoo challenge students may decide to grow lettuce, beans, or carrots tc feed the guinea pigs in the zoo.

During class discussions, students decide what plants to grow for the purpose they have determined. The students may decide to work in small groups, each group being responsible for a certain aspect of their project. In some classes each group might choose to work with a different type of plant, finding their own containers, researching the needs of the plants, conducting experiments to find their optimal growing conditions, and preparing information booklets on the plants if they intend to sell them or give them to others. In other cases, each group might be responsible to the class for a certain task, such as scrounging or buying materials for raising plants, germinating seeds or rooting stem cuttings, experimenting with conditions of light, soil, and water, or constructing plant boxes, artificial light systems, or greenhouses.

Students might first experiment to find the best methods for rooting or germinating. For example, they might try to find out whether seeds germinate better in the light or in the dark, in water or in soil. While waiting for seeds to germinate and cuttings to root, the students can research plant needs from books. After the young plants sprout, the children might experiment to find out for themselves what

conditions make the plants grow the fastest. They may measure root length or plant height and record their data in a chart or log. They may make bar graphs or line graphs of results that may be used to provide proof for their reccommendations in booklets or displays on plant care.

Experience has shown that students should choose a wide variety of plants in case they find some types difficult to grow. Classes have also found it advantageous to grow extra plants of the same type in order to have an adequate number of seeds that germinate and plants that survive. Students may also find controlled experimentation with growing conditions worthwhile to insure that some plants survive; if they are not sure how much light (or food or water) a plant requires, they may give more to some plants than others and keep records of the results.

Students grow plants in clay pots, milk cartons, paper cups, or other materials brought or scrounged. As their nursery grows, they may want to build wooden planters to hold large numbers of plants. They may make hanging baskets for pots using macrame made from yarn or nylon twine. If the plants are not receiving enough natural light to keep them healthy, the students might erect a fluorescent tungsten light system attached to a timer to provide additional daylight hours for their nursery. To keep plants from drying out over weekends or holidays, the children make plans to take them home or construct a "portable greenhouse" from clear plastic, which retains moisture but admits light.

In many cases, classes grow plants to give or to sell to someone else or to display at some event. They prepare booklets or exhibits to explain how different plants are grown. Information on plant care may include lighting and watering instructions, what fertilizer to use (if any,) and how to guard against insect pests or disease. Students may use results from their own experiments to document their advise.

The children's interest in Growing Plants may lead to experimentation with growing plants under special conditions (such as hydroponics) or transplanting plants grown during work on the unit into a garden or park outdoors. Work on the challenge could also lead to other USMES units, such as Nature Trails or Classroom Design (using plants to improve the classroom environment).

Although many of these activities may require skills and concepts new to the children, there is no need for preliminary work on these skills and concepts because the children can learn them when the need arises. In fact, children [illegible]rn more quickly and easily when they see a need to learn.

Consider counting: whereas children usually count by rote, they can, through USMES, gain a better understanding of counting by learning or practicing it within real contexts. In working on Growing Plants, children also learn and practice graphing, measuring, working with decimals, and dividing to find averages or percentages.

2. CLASSROOM STRATEGY FOR GROWING PLANTS

The Growing Plants unit is centered on a challenge--a statement that says, "Solve this problem." The success or failure of the unit depends largely on (1) the relevance of the problem for the students and (2) the process by which they define and accept the challenge. If the children see the problem as a real one, they will be committed to finding a solution; they will have a focus and purpose for their activities. If the students do not think the problem affects them, their attempts at finding solutions are likely to be superficial and lacking in direction.

The Growing Plants challenge--"Grow plants for________"--is general enough to apply to many situations. Students in different classes define and reword the challenge and thus arrive at a specific class challenge. "Grow plants to sell at the school fair" might be one class's interpretation of the challenge.

The Process of Introducing the Challenge

Given that a problem exists, how can a teacher, without being directive, help the students identify the challenge that they will work on as a group? There is no set method because of variations among teachers, classes, and schools and among the USMES units themselves. However, USMES teachers have found that certain general techniques in introducing the challenge are helpful.

One such technique is to turn a class discussion about plants toward a Growing Plants challenge. For example, the teacher or a student might bring plants into the classroom, or the class might visit a nearby greenhouse or a botanical garden. The class might then discuss whether it would be feasible to grow plants in the classroom and what reasons they would have to grow plants.

A sixth-grade class discussed a display of houseplants at a large downtown department store. When the students recalled how expensive the plants

were, the teacher asked whether it would be possible to set up a classroom nursery to raise large numbers of houseplants inexpensively. The class conceived the idea of selling stock to raise money for buying materials and then selling the plants they raised at the school carnival in May.

A Growing Plants challenge may arise from the children's work on another USMES unit. For example, children working on the Classroom Design unit may decide to grow plants in certain sections of the room to improve its appearance; children working on School Zoo may decide to grow vegetables to feed some of their animals.

When children working on another USMES challenge encounter a problem that leads to a Growing Plants challenge, one group of children may begin work on this second challenge while another group continues on the first. However, there should be at least ten or twelve students working on any one challenge; otherwise the children's work may be fragmented or superficial or may break down completely.

The Growing Plants challenge may also evolve during a discussion of a specific topic being studied by the class. A class studying plant physiology might decide that they can learn more by growing plants in the classroom and observing them.

Sometimes the discussion of a broad problem may encompass the challenges of several units. For example, a discussion of how to raise money for a class trip could lead to a Manufacturing, a Soft Drink Design, or a Growing Plants challenge, while a discussion of how to improve the appearance of the classroom could lead to a Classroom Design or a Growing Plants challenge.

A sixth-grade class held a discussion to think of ways of raising money for a school camping trip. Several suggestions were made; then the teacher suggested that the children grow plants for sale and use the money for the trip. The students were overwhelmingly enthusiastic and set up a "Flower Shop." Each person in the class contributed an equal amount of money for buying supplies, and the students bought marigold seeds and raised them into plants.

A third-grade class began work on Growing Plants by discussing what could be done to improve the appearance of their room. Some children in the class suggested that they grow plants to make the room more attractive, and the class accepted this as their challenge. They planted a wide variety of plants, constructed shelves and planters, made hangers from macrame, and hung plants or placed them on shelves around the room to meet the challenge.

An experienced USMES teacher is usually willing to have the children work on any one of the several challenges that may arise during the discussion of a broad problem. While this approach does give the children the opportunity to select the challenge they are most interested in investigating, it also places on the teacher the additional responsibility of being prepared to act as a resource person for whichever challenge is chosen.

Classroom experience has shown that children's progress on a Growing Plants challenge may be poor if the teacher and students do not reach a common understanding of what the challenge is before beginning work on it. Having no shared focus for their work, the children will lack the motivation inherent in working together to solve a real problem. As a result, they may quickly lose interest.

A similar situation occurs if the teacher, rather than ensuring that the children have agreed upon a challenge, merely assigns a series of activities. Although the teacher may see how these activities relate to an overall goal, the children may not.

A fourth/fifth/sixth-grade class worked on growing plants to keep in their classroom. They tried several methods of growing plants, such as from seeds, roots, or stem cuttings. The teacher asked the children to write down observations and to keep graphs on plant growth. However, the purpose of growing the plants had not been defined, and later in the year, the children argued over who should get the chance to take home the plants which were grown by the whole class.

Initial Work on the Challenge

When children begin work on their challenge, they list various tasks that need to be done, such as choosing and ordering seeds and obtaining pots or making boxes in which to grow the plants. Next, they usually categorize these tasks and set priorities for completing them. Most of these tasks are carried out by small groups of children. For example, one group might choose to make price comparisons of seeds from various sources, while another might research the needs of various plants.

Children in a fifth- and sixth-grade class worked on the challenge of growing house plants for a plant sale. They began by dividing into three groups to look up information in books about plants, surveying adults and children to find out the most popular plants, and phoning florists and other experts to find out what plants could go in their room. After these initial activities, however, the children began working individually or in pairs to research information on the plants they had chosen and to make charts and booklets on plant care. Several children were upset when they discovered that the charts on plant care which they were working on had already been done by other people. The class suggested that finished products should be put up on the bulletin board and that people should always walk around the room to see what was being done before starting something new.

A fourth-grade class chose to work on growing vegetables to feed the guinea pigs in the school. The children decided to make a garden, but they realized they needed to know several things before they could begin growing plants. After much discussion the children decided to divide into groups to find out how much food the guinea pigs ate, what they ate, and how to feed the guinea pigs in the meantime. Another group formed to make plans for the garden. The children went off to work in the various groups, and reconvened to report their findings at the end of the session.

As various groups complete their work, their members join other groups or form new groups to work on additional tasks. Sometimes, after the seeds or cuttings have been obtained, the students will form new groups, one for each type or group of plants. However, if too many groups are formed, work on the challenge can become fragmented. The teacher finds it impossible to be aware of the progress and problems of each group; in addition, having only one or two students in each group lessens the chance for varied input and interaction.

As the unit progresses, USMES sessions should be held several times a week, but they need not be rigidly scheduled. The children will need to prepare and follow regular schedules for watering, fertilizing, and otherwise caring for the plants. (The teacher may help by suggesting that they try alternative ways of making sure that these things get done.)

Refocusing on the Challenge

During work on Growing Plants, the children's attention should, from time to time, be refocused on the challenge so that they do not lose sight of their overall goal. Teachers find it helpful to hold periodic class discussions that include group reports on student investigations. Such sessions help the students review what they have accomplished and to determine what still needs to be done. These discussions enable the students to be aware of what other groups are doing, to evaluate their own work, and to exchange ideas. Without these sessions there is a strong possibility that the children's efforts will overlap unnecessarily.

Resources for Work on the Challenge

When children try to decide on solutions before collecting and analyzing enough data or when they encounter difficulties during their investigations, an USMES teacher helps out. Instead of giving answers or suggesting specific procedures, the teacher asks open-ended questions that stimulate the students to think more comprehensively and creatively about their work. For example, instead of telling the students to plant enough seeds, the teacher might ask the students what they will do if some seeds don't germinate and some plants die. Examples of other nondirective, thought-provoking questions are given at the end of this section.

The teacher may also refer to the "How To" Cards or the "How To" Series pertinent to Growing Plants for information about specific skills, such as collecting data or drawing graphs. If many students or even the entire class need help

in particular areas, teachers should conduct skill sessions as these needs arise. (Background Papers on topics relating to Growing Plants activities may be helpful.)

USMES teachers can also assist students by making it possible for them to carry out tasks involving hands-on activities. If the children's tasks require them to design and construct items, such as plant boxes, the teacher should make sure that they have access to a Design Lab. Any collection of tools and materials kept in a central location (in part of the classroom, on a portable cart, or in a separate room) may be called a Design Lab.

Valuable as it is, a Design Lab is not necessary to begin work on Growing Plants. The Design Lab is used only when needed, and, depending on the investigations chosen by the children, the need may not arise at all.

A third-grade class worked on growing plants without the use of a Design Lab. Children planted flower and vegetable seeds in milk cartons and then constructed "greenhouses" for the plants from cardboard or wooden boxes covered with clear plastic.

To carry out construction activities in schools without Design Labs, students may scrounge or borrow tools and supplies from parents, local businesses, or other members of the community. The extent to which any Design Lab is used varies with different classes because the children themselves determine the direction of the Growing Plants investigations.

A fifth-grade class built a large greenhouse for growing plants at one end of the classroom. The children received tools and advice from several parents who became involved in the project and completed the entire structure within a few days. They first built the wooden frame, then a peaked roof, and then the door. They covered the frame with plastic sheeting and rigged four fluorescent light fixtures to supplement the sunlight coming from a window.

Culminating Activities

As in every USMES unit, Growing Plants activities come to an end when children have succeeded in finding and implementing a solution to the challenge. This may result in a plant sale, a class trip to an institution to give plants to elderly or sick people, or preparation of an "open house" where reports, posters, and the class nursery are displayed for other students. The students may also prepare booklets on plant care for the plants they sell or give away. Without some type of culminating activity or discussion, many classes have difficulty determining if or when they have reached a solution to the challenge.

The fourth-grade class with the challenge of growing food for the school guinea pigs and rabbits decided to let the animals themselves evaluate their work. When the radishes were ready, the children gave them to the six guinea pigs in the classroom and watched their responses. They noted that two guinea pigs loved the radishes, one "sort of liked them," and the other three ate only the radish leaves. However, all the rabbits and guinea pigs in another classroom liked the radishes. The lettuce, which matured later, was eaten (and appreciated) by all the rabbits and guinea pigs in the school

3. USE OF GROWING PLANTS IN THE PRIMARY GRADES

Most young children enjoy caring for living things and will be enthusiastic about the challenge of growing plants in the classroom for a particular purpose. Primary children will respond readily to the idea of growing flowers as gifts or vegetables to serve at a holiday dinner. A third-grade teacher introduced the challenge of growing in the classroom plants which would bloom by Mother's Day. Because the classroom is an important environment for young children, a class might also respond enthusiastically to the challenge of growing plants to make the room more attractive. Two third-grade classes chose this challenge to work on and were proud of the appearance of their room when the plants were hung or placed around it. In some primary classes, children may respond more quickly to the idea of growing plants if some plants have been kept in the classroom

environment for a few days prior to the introduction of the challenge.

Children in the primary grades may choose to grow most of their plants from seeds, as this is often more exciting than rooting cuttings. One third-grade class, however, succeeded in growing a sweet potato plant from the root, while their efforts to germinate an avocado seed failed. The most popular plants grown in several primary grades included vegetables and fruits such as beans, corn, tomatoes, carrots, radishes, citrus plants, and flowers such as zinnias, petunias, and marigolds.

Primary children may work for several weeks on the Growing Plants challenge as they plant seeds, transplant larger plants, and observe and record information on the growth of their plants. Young children will often want to have their own plants, particularly if they are growing them for personal gifts. To conduct experiments to find out the best conditions for germinating seeds or growing plants, children will usually find it advantageous to work in a group with children who are growing the same type of plant. One second-grade class ran a class experiment to test which of three methods was the best for germinating pea seeds: using wet paper towel, using water, or using soil.

Measurement skills are learned as primary children measure plants to find out how fast they are growing or which ones are the biggest in a controlled experiment. Children in a third-grade class made a chart for recording when each set of seeds were planted, what day "the seed popped up," and weekly measurements on each plant.

Making bar or line graphs to show how fast plants grow or to compare plants grown under different conditions is not an activity easily initiated by children themselves; often they have only a minimal understanding of graphing concepts at the primary level. Children might better understand graphs by cutting strips of paper to the desired length and sticking them on paper. They might then go on to make graphs using graph paper. After several skill sessions on graphing, children in a second-grade class were able to make their own bar graphs showing plant growth over a period of a few weeks by drawing in the height of each plant daily.

If the children want to find the average height of several plants, they can use medians which are easy to find rather than trying to calculate means. In keeping track of germination time, the children might, as each plant appears, drop a marble into one of several tubes representing days; in effect this results in a histogram. Children can compare the percentage of different types of seeds

which germinate by drawing a slope diagram.

Children also practice language and art skills by keeping logs on their plants, making colorful bulletin board displays of the plants in their room, and/or drawing pictures of their plants to record changes in their appearance. Children in one third-grade class made pictures of their plants at three different stages of growth to show how they changed.

If the need arises, most primary classes will be able to construct simple containers or greenhouses for growing their plants. Children in one third-grade class made planters and shelves for their plants in the Design Lab. Several primary classes found it advantageous to make simple greenhouses from wooden or cardboard boxes covered with clear plastic to prevent their plants from drying out over weekends or holidays.

4. FLOW CHART

The following flow chart presents some of the student activities--discussions, observations, calculations, constructions--that may occur during work on the Growing Plants challenge. Because each class will choose its own approach to the challenge, the sequences of events given here represent only a few of the many possible variations. Furthermore, no one class is expected to undertake all the activities listed.

The flow chart is not a lesson plan and should not be used as one. Instead, it illustrates how comprehensive investigations evolve from the students' discussion of a Growing Plants problem.

Challenge: *Grow a plant for __________. (Children determine the specific purpose such as for gifts, for transplanting into a garden, for sale, etc.)*

Optional Preliminary Activities:

USMES Unit: Classroom Design

USMES Unit: School Zoo

USMES Unit: Nature Trails

Field Trip to botanical gardens or florist.

Possible <u>Student</u> Activities:

Teacher or student brings plants or seeds to the classroom. Students observe and care for them informally.

<u>Classroom Discussion</u>: Why do people like plants? How are plants useful and interesting? What could we do with plants if we had some? How can we grow some plants in the classroom (for the specific purpose decided upon)? Plant needs are listed and things to be done identified: research, experiments, surveys, etc.

<u>Preliminary Data Collection Activities</u>: Seeds germinated, cuttings rooted. Initial experiments with per cent germination, rooting using different media or light conditions.

<u>Data Representation</u>: Line graphs comparing root growth under different conditions, triangle diagrams comparing per cent germination of different seeds are made.

Materials are bought or scrounged: containers for planting, soil, fertilizer, plants, cuttings seeds.

Library research conducted, visits to greenhouses made to find information on growing conditions.

Survey of student or adult plant preferences conducted.

<u>Class Discussion</u>: Children discuss rooting and germinating data, survey results, and growing conditions of room and make list of plants to grow. They identify other experiments, construction projects, and other activities necessary. New groups are formed.

Data Collection: Rooting and germination experiments continued on specific plants. Best growth conditions (soil, water, light, fertilizer) determined through controlled experiments or tests.

Data Representation: Line graphs comparing plant growth under various conditions; bar graphs to show daily growth of individual plants are made.

Library research continued to find needs of specific plants, information on disease or pests, etc.

Feeding and watering schedules established for plant maintenance.

Planters or shelves constructed for housing plants.

Class Discussion: Results of growth experiments, library research discussed. List of plants to be grown is modified, suggestions made for modifying care of plants and decided upon. Care of plants over holidays arranged. Location and arrangement of plants discussed.

Data Collection: Children continue experimenting with best conditions to grow plants. They keep growth records and record observations in daily logs.

Any additional graphs are made and analyzed.

Plants transplanted to larger pots. New seeds and cuttings started according to previously determined propagation conditions.

Feeding and watering schedules are modified.

Greenhouses or artificial light systems designed and implemented if additonal moisture or light is necessary.

Class Discussion: Plans made for giving away, selling, eating, or transplanting plants grown. How do we prepare information so that other people care for them properly?

Design advertising displays, campaigns if sale is intended.

Plants transplanted to attractive pots (macrame hangers made for hanging plants) for sale or gifts. Vegetables or flowers transplanted to gardens.

Booklets on plant care made for sale or gifts to help people care for the plants they receive.

Preparation for Open Houses made: displays, demonstrations made to share information with others.

Optional Follow-Up Activities:

USMES Unit: School Zoo

USMES Unit: Manufacturing

USMES Unit: Nature Trails

USMES Unit: Advertising

5. A COMPOSITE LOG*

This hypothetical account of an intermediate-level class describes many of the activities and discussions mentioned in the flow charts. The composite log shows only one of the many progressions of events that might develop as a class investigates the Growing Plants challenge. Documented events from actual classes are italicized and set apart from the text.

Shortly after school begins in the fall, the class holds a discussion to talk about what to do for the annual school fair in May. Some children mention that they could make craft items such as pottery and macrame; others favor an art display. One child adds that they should do something that would be interesting for everyone and that would "teach them a lot." A student with an interest in biology suggests growing plants for the fair, and the idea takes hold immediately. The children are aware that houseplants are very popular; almost everyone has some houseplants, and coleus and Swedish ivy plants are growing in a window in the classroom. When someone suggests that they could sell the plants to parents and kids at the fair, the rest of the class responds favorably. One girl instantly reminds the class of a camping trip which has been planned for June, suggesting that they use the money raised from plant sales to pay for the trip. The class is enthusiastic about this idea.

A teacher in a fourth-grade class in Cotuit, Massachusetts, asked the students in the class what they could do about feeding the large number of guinea pigs and rabbits in the school. Various children proposed solutions, including bringing food scraps from home, selling things to raise money, and giving away all the animals (which was vetoed immediately.) After much discussion, the children decided to make a garden and grow food for the animals. Everyone was enthusiastic about this, and they immediately began listing things that needed to be done. (From log by Phyllis Viall Cooper.)

A sixth-grade class in Monterey, California, began work on Growing Plants by discussing a display of houseplants in a large department store. When the teacher asked the children if they thought they could raise large numbers of plants and sell them at a lower price than the department store, the class devised the challenge of growing plants for sale at the school carnival in May. (See log by Steven Hanson.)

When their classroom was destroyed by fire, children in a third-grade class in Boston, Massachusetts,

were moved to another, less comfortable room. One of the first things they wanted to do was to improve the appearance of their room. They eagerly began work on the challenge to "grow plants to make the room more attractive" and began raising a variety of plants to decorate the classroom. (From log by Patricia Parolski.)

The following day the class holds another discussion to determine how they will begin to grow their plants. After many suggestions are made, the children decide that they need to make a list of things to be done. One student begins writing the students' suggestions on the board. But some students feel that before they can do anything, they need to know more about plants and plant care. The class agrees to plan a trip to a local greenhouse for the following session, and they list the things that they need to find out during their visit:

1. Check prices of supplies, such as fertilizer, pots, potting soil, young plants, etc.
2. List number of plant types available and their names.
3. Ask questions to find out how to grow plants, plant seeds, make cuttings, etc.

The class divides into three groups to find out this information. Two days later, they make their trip to the greenhouse.

After their visit, the children hold another discussion to go over what they have learned about plants and materials needed and to decide what needs to be done. They make a new list of the things they need to find out and how they expect to do this:

1. What are the best prices for our materials (soil, pots, etc.)? Call other greenhouses and supply places.
2. What plants are the most popular and will sell best? Take a survey of kids.
3. What do plants need to grow? Look up in books.
4. What's the best way to make cuttings or grow plants from seed? Experiment with different ways.

The students decide to divide into groups to work on finding out this information. They call their groups the Finance Group, the Survey Group, the Reference Group, and the Experimentation Group, respectively.

The Monterey class planned to raise money for supplies for growing plants by selling stock in a company and then to sell the plants for a profit at a school carnival. The class listed five things that needed to be done and broke into five groups to work on them: (1) survey buyer preferences for plants, (2) reference information on plants in books, (3) sell stock to raise money, (4) buy supplies with money raised, and (5) build a greenhouse for the plants with money raised. (See log by Steven Hanson.)

The group that is calling greenhouses and supply houses to find the cheapest prices checks on the cost of potting soil, perlite, and small plants. They manage to find a wholesale pot outlet which sells pots for 5¢ each. Although they are able to figure out ways to save money when purchasing supplies, children in this group are still concerned about the cost of materials. In a class session to discuss the findings of the different groups, the Finance Group raises the question of where they are going to get the money (estimated at $30) to buy supplies. Someone suggests that they ask the PTA for a loan of $30 to be repaid after the fair. When the class agrees to this, the Finance Group begins to plan a presentation for the next PTA meeting.

The Survey Group decides to set up a table during lunch to ask children which kinds of houseplants they prefer. One student suggests that they bring in plants to put on their table "because otherwise, they won't know what all the different kinds look like." The group decides that this is a great idea, and the children arrange to bring different kinds of plants from home. Some plants are mentioned which no one has at home; the children decide to check books on houseplants with large color photographs out of the library so that they can exhibit pictures of these plants while they are taking the survey.

One group of students in the Monterey class compiled a list of about twenty house plants which students had in their homes. They displayed several of these in front of the cafeteria and asked other students to pick their favorites. The group then determined the most popular plants to grow, including coleus, wandering Jew, asparagus fern, and jade tree. (See log by Steven Hanson.)

One student brings up the point that adults would be at the fair, too, and therefore should have input in picking the most popular plants. The children try to think of a way to show the plants to adults so they can choose the ones that they like best. The group decides to accompany the Finance Group to the next PTA meeting and ask the parents and teachers present which plants they prefer.

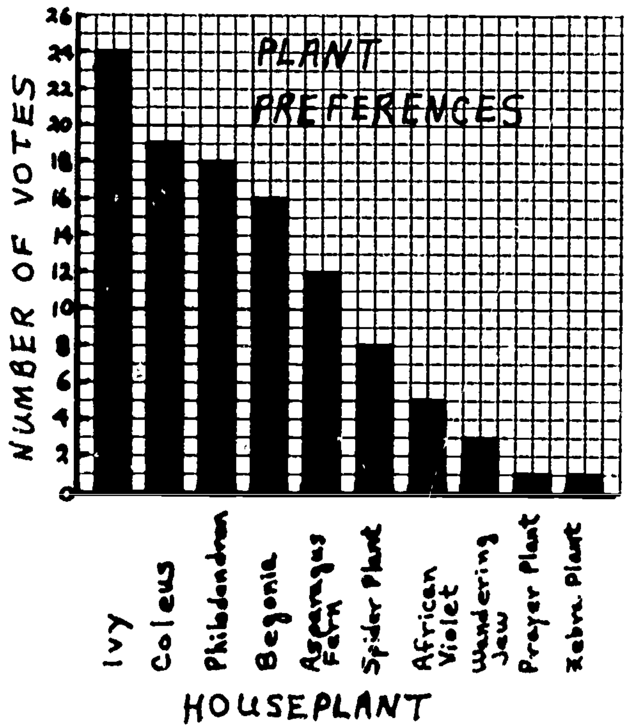


Figure B5-1

A fifth- and sixth-grade class in Burnsville, Minnesota, decided to grow plants to sell at a school fair in the spring. The children made plans to choose plants to sell by surveying anyone who knew about plants. One group developed a questionnaire to use while interviewing other teachers in the school while another group conducted a phone survey of local florists. They told each person about the lighting and temperature conditions in their classroom, asked what types of plants would grow best under these conditions, a.. compiled a list of about twelve plants from the responses. (From log by Sandra Aken.)

Before they conduct their survey, the children decide that it would be easier to figure out results if they ask each person to choose their favorite plant rather than listing several preferences. After they survey both children and adults, they add the results and make a bar graph of the number of votes each plant receives. They find that the five most popular plants are ivy (several varieties), coleus, asparagus fern, philodendron, and begonia. (See Figure B5-1.)

Meanwhile, the Research Group has checked books out of the library to obtain information on plants. The children read about how plants germinate, how they use light and

ROOT LENGTHS (mm)

I. Rootone and Water

Plant No.	Number of Days 5	8	12	16
1	0	0	1	9
2	0	0	2	2
3	0	2	3	9
4	0	0	4	12
5	0	1	5	6
Mean Root Length	0	1	3	8

II. Soil and Water

Plant No.	Number of Days 5	8	12	16
1	4	12	50	88
2	0	3	40	70
3	12	39	62	65
4	0	0	9	50
5	10	34	71	77
Mean Root Length	5	18	46	68

Figure B5-2

water, and what nutrients they need from the soil. They report this information to the rest of the class. The group also looks up needs of individual plants and discovers which plants need more water, light, or plant food than others.

The Experimentation Group divides in half during their first meeting; part of the children want to work with planting seeds while the rest decide to try rooting cuttings. The seed-starting subgroup decides to begin by planting some coleus seeds from a packet that the florist gave the class on their trip to the greenhouse. They try planting some seeds in potting soil and others wrapped in a paper towel held vertically in a jar with water at the bottom. The jar method seems more successful, as they forget to water the soil and the seeds take a long time to sprout.

They decide to run a germination test on the coleus seeds they have been given (as the florist had suggested). Carefully counting fifty seeds ("We would have counted 100 but we got tired because they are so small," one girl says), wrapping them in a paper towel, and setting this in a jar full of water, the children wait about ten days and then spread the paper towel out to count the seeds. They find that thirty-five seeds have germinated, and they calculate a germination rate of seventy per cent. From this test, they conclude that the seeds are pretty good and decide to donate the rest of the packet to anyone who wants to work with coleus.

A second-grade class in Arlington, Massachusetts, began work on Growing Plants by conducting a germination experiment with peas. They planted six seeds in water, six in a wet paper towel, and six in soil. The children noted that the seeds in water sprouted first but that the others caught up fairly quickly. They also noticed that seeds left too long in water or a wet paper towel grew mold. Most of the children decided it would be safest to try to sprout their seeds in dirt. (From log by Mary Lou Rossano.)

A fifth-grade class in Durham, New Hampshire, scrounged several types of seeds, some of which were several years old. One boy who had learned how to run germination tests in Boy Scouts demonstrated these tests to other children. The

children learned how to wrap 100 seeds in a paper towel, set them in water, and watch how many germinated. They discovered that only 30% of the seeds that were more than one year old germinated, and they concluded that older seeds were not good to use. (See log by Peter Schiot.)

The subgroup trying to root cuttings takes ten slips from two Swedish ivy plants in the room. They cut them just below the last set of leaves, then dip five in Rootone (a chemical hormone substance used to stimulate root growth) and set them in jars of water. The other five they set in jars of water to which a tablespoon of garden soil has been added. The children explain during a class session that they are comparing an inorganic (Rootone) method vs. an organic method (soil) of rooting.

They begin by taking counts of the number of roots each cutting has sprouted as well as the length of the longest root. As the roots get larger, the children begin to feel that the root length is more important than the number and continue to take measurements (in millimeters) of the longest root for each cutting every few days. They notice that, surprisingly, the cuttings in soil and water are rooting much faster than those in Rootone and water. (See Figure B5-2.)

After sixteen days, they transplant the cuttings with the longest roots and discuss how they can show the class the results of the experiment. They decide that they need to find one number that will represent the results from the five cuttings that were used in each part of the experiment. Since they have been working on means (averages) in math, they agree to find the mean (average) of each set of measurements.

To calculate mean root lengths, they add all the measurements of each day under each set of conditions (rounding off to the nearest millimeter), divide by the number of plants, and plot the points on a line graph which shows mean root length vs. number of days.* A graph (see Figure B5-3) shows conclusively that the Swedish ivy cuttings have rooted better in soil and water than in Rootone and water. The children consider telling the rest of the class not to

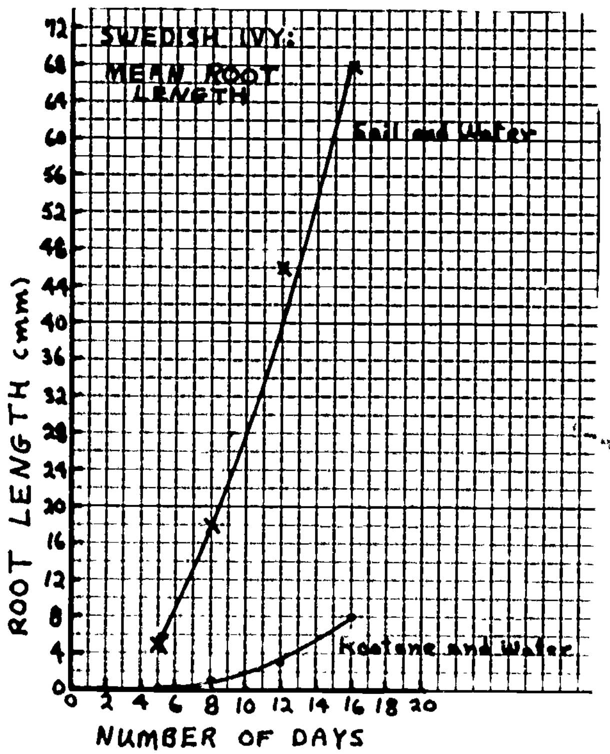


Figure B5-3

*Younger children can use the median number instead of the mean. See "How To" Series booklets on medians.

PLANT STEM HEIGHTS (cm)

I. Plants Grown in Dim Light

Plant No.	Number of Days				
	0	7	12	16	21
1	9.2	9.2	9.5	9.5	9.8
2	7.0	7.0	died	—	—
3	9.5	9.5	9.7	9.8	9.9
4	7.9	8.3	died	—	—
5	6.0	6.0	6.7	6.7	7.6
6	6.0	6.4	6.7	7.0	7.1
Mean Height	7.6	7.7	8.1	8.3	8.6

II. Plants Grown in Bright Light

Plant No.	Number of Days				
	0	7	12	16	21
1	9.8	9.8	11.4	11.8	14.0
2	9.2	9.5	10.5	10.8	12.7
3	7.9	8.6	9.5	9.5	11.4
4	9.2	9.8	11.1	11.8	12.7
5	9.8	10.8	11.8	12.7	16.2
6	8.9	9.8	10.2	10.5	11.8
Mean Height	9.1	9.7	10.8	11.2	13.1

Figure B5-4

use Rootone to root cuttings of houseplants, but one student points out that the results might be different for other kinds of plants. The group agrees that anyone growing another kind of plant should make their own tests.

Children in the sixth-grade class in Monterey experimented to find out how plants rooted under various conditions. A group which rooted some cuttings in Rootone and water and others in water without Rootone found that Rootone did not seem to improve root growth. Another group found that coleus cuttings rooted faster in light than in the dark. Some children made bar graphs or line graphs of their results. (See log by Steven Hanson.)

When each group has researched the necessary information, the class holds a discussion to decide which plants to grow and to make plans for growing them. They check the information obtained by the Reference Group with the list of most popular plants determined by the Survey Group and decide that the plants they have chosen will grow well in the classroom. The children decide to break into five groups, each working with one of the plants on the list. They divide according to which plant they want to grow, trying to keep the numbers in each group as equal as possible.

Within each group, some children decide to find as much information as possible on their plant from library books on houseplants or from local plant experts. Other children conduct experiments with lighting, soil, fertilizer, or water to see how plants grow best. The children keep growth records on nearly all of the plants, and some write logs to keep track of their progress, noting when a plant first roots, if it dies or flowers, or the date when it is transplanted to a larger pot.

The children in a third-grade class in Arlington, Massachusetts, kept growth records on their vegetables and flowers. They carefully noted which seeds sprouted first, which plants grew most rapidly, and in which part of the room the plants grew best. (See log by Barbara Fischer.)

Students in the Coleus Group decide to experiment with lighting conditions for their plants. They measure the heights of twelve coleus plants, place six of them in a sunlit window, and keep six in a dark corner of the room. The children make periodic measurements over several weeks to determine how the plants grow. (See Figure B5-4.) After one week, children note that the plants in the dark corner look sickly, and they remove them to the middle of the room so that they will receive fluorescent light. In spite of this, two of the six plants die and the others lose their brilliant colors.

The children decide to graph the results of their experiment so that they can compare the growth rates of the two sets of plants. After talking with the group that worked with data on root length, they decide to find means. For each of the two sets, they find the mean of all the heights for each day that they have measured. As they have measured the heights to the nearest 0.1 centimeter, they decide to round off the means to the nearest 0.1 also.

The group argues over what to do with the two dead plants in figuring the mean height for the twelfth day of the plants grown in dim light. Some children think that, rather than redoing the experiment, they should record the height for each as zero and find the mean for all six plants, but the children finally decide that they will use only four plants in calculating the means for the remainder of the measurements. They plot the points on the graph, draw a smooth line connecting each set of points, and make note on the graph of the two plants that died. (See Figure B5-5.) The group concludes from this experiment that coleus should be grown in bright light.

Other groups conduct experiments to find out how much water or fertilizer their plants need. Two groups also experiment with making potting soil out of peat moss, garden soil, and perlite and compare this medium to commercial potting soils.

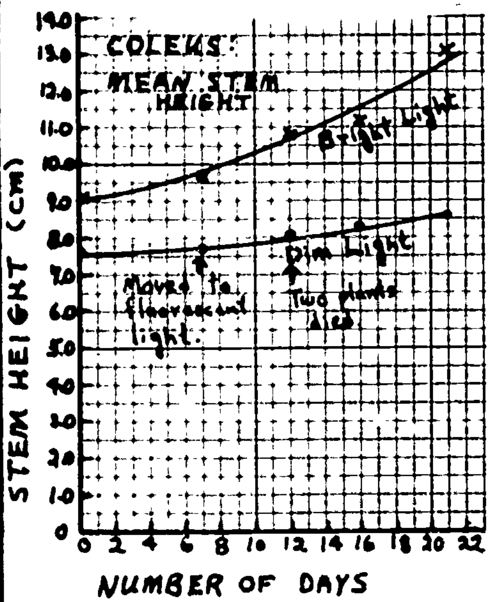


Figure B5-5

A sixth-grade class in Lexington, Massachusetts, decided to grow marigolds and sell them to raise money for a class trip. To find out how much fertilizer was best for their plants, they squirted each plant box with varying amounts of plant food and water. The children kept records by measuring the height of each plant every day and recording

it on a bar graph. They found that plants did best with a moderate amount of plant food. (From log by Robert Farias.)

Children in the Durham class experimented to find ways to improve the type of potting soil they used to grow plants in the classroom. Finding that local soil had too much clay and that commercial soil cost too much, they developed their own mixture from peat moss and deactivated sludge from the local sewage treatment plant. The children also treated other soils for pH and nutrient content and found ways to improve them by adding natural ingredients such as wood ashes or compost. (See log by Peter Schiot.)

From time to time the five plant groups meet to discuss their progress and various problems they have encountered. One of the common problems is over-watering. Although some groups have experimented to find the optimum amount of water to use on their plants, many children still feel that the more water a plant receives, the more it will grow. Some plants are also being watered twice because children are uncertain whose turn it is to water. The class decides that each group should make a watering schedule for the plants so that on the days when they are not working on the unit, one or two people are responsible for watering or misting the plants.

The third-grade class in Arlington had problems with over-watering of plants. During a class discussion the children decided that each person should be responsible for watering his/her own plants. Children who over-watered were urged to use the spray bottle, and the plants belonging to the whole class were put in charge of the children who loved to water plants. (See log by Barbara Fischer.)

The sixth-grade class in Monterey set up a rotating schedule for watering their plants and made a color-coded chart to show how often various plants should be watered or misted. They made a

new chart when they discovered that coleus should not be misted daily because the eaves lose color. (See log by Steven Hanson.)

When vacation time arrives, the children debate whether to take their plants home to be cared for or to have someone come in every few days to water the plants. One child reads in a book that clear plastic bags put over the plants will prevent moisture from escaping. "Then, the plants can use the same water over and over again," she says. The children decide to make their own "plastic greenhouses" by covering plants with plastic bags and large sheets of transparent plastic from dry cleaning establishments. When they return from vacation, the plants are still moist and healthy-looking. They decide to put the plastic over some of their plants each weekend from then on.

Children in the second-grade class in Arlington covered their plants with plastic wrap over each weekend. When they began discovering mold growing on the soil, they allowed the plants to dry out thoroughly when the plastic was removed before watering them again. (From log by Mary Lou Rossano.)

Children in the Durham class constructed a greenhouse in their classroom from wood and plastic sheeting with the help of some parents. They hung fluorescent lights in the structure to supplement sunlight from a nearby window. The children found that most of the vegetables and annual flowers which they grew in the greenhouse thrived in the warm, moist atmosphere; however, they discovered that this environment was too hot for raising lettuce. (See log by Peter Schiot.)

Children from several of the plant groups begin bringing in all kinds of vegetable and flower seeds and planting them in egg cartons or milk cartons. Many of the children feel that starting seeds is more exciting than rooting cuttings, and they convince the class that these kinds of plants might also be popular at a plant sale. The children working with

these plants form new groups for planting the seeds, carefully labelling them, and recording their growth. When the seedlings become too large for their containers, they transplant them into larger ones, being careful to leave enough space around each plant to allow for growth.

As the number of plants in the classroom increases, groups begin to compete for space near the window, where the light is best. The class holds a discussion to figure out what to do about this problem, and the children decide to construct shelves for their plants which can be placed next to the window. One child whose mother has taught him macrame mentions that they can make macrame hangers for some of the larger plants and hang them from hooks next to the window, thus decreasing the number of plants on the windowsill. The children decide to form new groups to work on these projects. Some of the children go to the Design Lab to work on making wooden shelves, while others use twine and begin learning how to make the macrame knots necessary for hangers.

Children in the third-grade class in Arlington constructed wooden planters in the Design Lab for many of their larger plants. They also made macrame hangers using lengths of different colored twine. Later in the year the children conceived the idea of constructing wooden shelves for many of their plants to conserve space. They hung other plants in various places around the room to help meet the challenge of using plants to make their room more attractive. (See log by Barbara Fischer.)

Children in the sixth-grade class in Monterey used a large box previously constructed by another class for growing their individually potted houseplants. During a class discussion the children decided that additional light would help the plants grow better, and they rigged a light system, consisting of a fluorescent fixture, an incandescent bulb, and a timer, over the plant box. They set the timer to give the plants an additional eight hours of light. (See log by Steven Hanson.)

In the spring the children begin to prepare for their plant fair. They decide to put most of the plants up for sale, but nearly every child also wants to take a plant home, and children discuss how this can be arranged so that everyone is happy. They also decide to form new groups for working on the fair. Some children volunteer to set prices, taking into consideration the size of each plant and what kind of container it is growing in. Hanging plants are set at the highest price levels. Another group forms to advertise the plant sale, preparing posters for placement around the school.

Other children work within their old groups to complete posters with drawings and information on their plants, such as how to start a plant from a cutting. Some groups prepare booklets on plant care. They mimeograph these booklets, make covers for them of construction paper, and sell them at the fair for 25¢ each.

Students in the Burnsville class prepared booklets and charts on plant care, lighting, terraria, and such plants as ferns, cacti, and philodendron. These were displayed at a plant sale which they held during the spring school fair. One girl also prepared a display on plant diseases and pests, including demonstration plants, charts of problems and remedies, and a booklet for sale. The children did extensive library research to find information for their displays at the fair and worked hard preparing attractive presentations. (From log by Sandra Aken.)

The plant sale at the fair is a great success. Large numbers of children and adults are attracted to the display and all the plants and booklets are sold. The children count the money they have made after the sale and find that after they repay the PTA loan, they still have another $32 left for the camping trip. They decide that they have met their challenge are are quite pleased with the success of their work.

Children in the sixth-grade class in Monterey were so pleased with the plants they grew that they decided to buy the plants themselves as Mother's Day gifts. The children had a long

discussion about whether to hold an auction or a fixed-price sale and finally compromised by auctioning the hanging plants and selling all the others at a fixed price. (See log by Steven Hanson.)

The fifth-grade class in Durham held an open house for other classes in the school to share what they learned from growing plants. Working in groups, the children gave demonstrations on macrame, making compost, testing soil for pH and minerals, starting seeds, and transplanting. Another group gave a tour of the greenhouse that the children had constructed. Many of the groups also sold some of their plants and macrame hangers or gave them away to the younger children. (See log by Peter Schiot.)

Many of the vegetables and flowers which the children have grown are still seedlings and are kept in the classroom until they are old enough to transplant. The children take these plants home to be transplanted into gardens.

A fourth-grade class in Boulder, Colorado, worked on the challenge of finding how to improve the soil for planting gardens. They experimented with adding various materials to soil containing a lot of organic matter, such as compost. The children then decided to use this information to help them grow vegetables in a garden next to the school. They planned to ask community organizations to help them care for the garden when school ended. (From log by Edward Schriner.)

6. QUESTIONS TO STIMULATE FURTHER INVESTIGATION AND ANALYSIS

- Why do people like plants? How are plants useful to people and (other) animals?
- How can we grow plants in the classroom for ____________ (feeding the guinea pigs, giving to sick people, making the school more attractive, etc?)
- What kinds of plants can we grow in the classroom? What kinds would be too hard to grow? How can we find out?
- How can we find out which plants would be the most popular (for other students, adults, guinea pigs)? How many people should we ask? How do we pick the people to ask?
- What will we keep plants in while we are growing them? When they get bigger?
- How many plants can we grow in the space we have? How can we get more space?
- What should we know about plants before we start to grow them? How can we find this out?
- What should we use to plant seeds in? How could we tell whether water, soil, vermiculite, etc. is best for growing seeds? How can we tell which type of seed germinates the best?
- How can we grow plants without planting seeds?
- How can we find out how much light a plant likes? How much water? What kind of soil? What kind of plant food?
- How many things can be changed in one experiment? How can we limit to one the things that change?
- What is a good way to keep a record of our measurements?
- How can we make a picture of our data?
- Are our plants healthy? What can we do to make them healthier?
- How can we keep plants from getting too dry over a weekend or a holiday?

- Do our plants need more light? What can we do to give them more light?
- How can we make our plants grow faster?
- Which plants grow fastest? Which grow slowly?
- How are your plants different from others in the room? How are they similar? How many ways can we group the plants in the room?
- Are our plants good to eat? Would any other animals think they are good to eat? How can we find out?
- How can we tell other people how to take care of plants?
- What kinds of information would other people want to learn about growing plants?

C. Documentation

1. LOG ON GROWING PLANTS

by Barbara Fischer*
Hardy School, Grades 2/3
Arlington, MA
(October 1974-June 1975)

ABSTRACT

Enthusiasm remained high throughout the year as this class of second and third graders at the Hardy School in Arlington, Massachusetts, worked almost daily on beautifying the classroom by growing plants. As a spin-off from this challenge the children also provided food for their two pet guinea pigs and for their own homes. At times, children eagerly stayed after school hours to continue projects, and many students began growing plants at home. At the outset, they generated a list of needed items, brought them in, and planted vegetables (e.g., cucumbers and string beans) and flowers (e.g., marigolds and morning glories) in milk cartons, plastic containers, or flower pots. Observations, discussions, and data recording of plant growth kept students busy as their projects progressed. Plants outgrew their containers, and so the class designed and built wooden planters and macrame hangers in the Design Lab. These roomier containers allowed the class to transplant and to have another planting session in which they experimented with various soil mixtures and worked with cuttings. One girl assembled a terrarium after doing background research. As class projects, the students tried growing avocadoes, sweet potatoes, and peanuts, sometimes analyzing initial failures and then succeeding on a second or third attempt. Vegetables became ready for transplanting outdoors before the ground had fully thawed, and the children agreed that in the future they would plant vegetables later. Abundance of plant life in the room sparked a discussion in which the class decided to build shelves to provide space in a single area for all the nonhanging plants. Time ran out with the shelves still under construction.

My class began the Growing Plants unit enthusiastically and maintained a creative and excited attitude working daily on the unit throughout the 1974-1975 school year.

*Edited by USMES staff

Chris Peter
1. dirt
2. water
3. seeds
4. corn
5. cucumbers
6. peanets
7. containers
8. grapefruit

Figure C1-1

The challenge grew out of a discussion about how we could improve our room. Some children suggested that we could grow plants to make our room more attractive, and this recommendation became our challenge. We might also be able to grow some food for our pet guinea pigs, some children noted.

In our first session, children described plants they had at their homes and discussed how to start growing plants and how to take care of them. They suggested we grow a variety of plants ranging from oranges and peanuts to flowers. Some pointed out that we might need more information before actually planting. Acting on this recommendation, two children went to the library to select some books that might prove helpful. Students consulted these books to identify plants they had seen in their homes and outdoors.

Some children offered suggestions for obtaining seeds, mentioning gardens, flowers, and actual fruits or vegetables. (This last possibility amazed many students.)

Working in groups, students compiled lists of things needed to start plants and keep them growing. (See Figure C1-1.). Then the children shared and discussed their lists and deemed the following items necessary:

1. dirt/soil--(half the students wanted to dig dirt from their yards, half planned to use potting soil)
2. pots--small clay or plastic pots, milk cartons, other (longer) cartons
3. drainage trays
4. rocks--to drain water
5. seeds--apple, string beans, grapefruit, flowers, carrots, cucumbers, lettuce, cabbage, sunflower seeds, tomatoes, peanuts, corn, radishes, peppers, watermelon, oranges
6. sun
7. water
8. shovels/scoops
9. labels--for type of plant and student's name

The day we had slated for planting arrived. Thanks to a cooperative student effort, all supplies on the master list had rolled in, and each child had his or her own container(s) ranging from milk cartons and plastic containers to flower pots. Before the class began planting, they discussed the

choice of seeds, how deep to plant each type, and how to water them.

Planting went smoothly. The children worked well together in this activity: sharing the soil and scoops, helping each other to choose seeds, and offering advice about planting. Everyone covered their seeds with soil, watered them, and put labels on the containers. They placed their projects in different parts of the room with different light conditions so that they could learn about the effect of light on plants. They even made sure to subject the same type of plant to different conditions. Past experience with plants in our room had taught us that our window sill doesn't offer an adequate growing environment (temperature varies too much), and so the plants temporarily sat upon two tables and a bookcase.

At the beginning of the next session, we realized the need to build something on which to place the plants. The class divided into groups, two of which chose to build narrow wooden benches, while the third opted to construct a wooden table (three feet by one and one-half feet).

As the groups produced these items in the Design Lab, I noticed that the children who had experienced USMES last year settled down to work more rapidly and had better concepts of what to do with their designs and how to use the tools. Both bench groups found it difficult to even up the legs, but they then discovered that removing the legs made sawing easier. Students in the other group turned out a very sturdy table on which they proudly fit a number of the plants.

Before mid-October, several of the containers boasted little shoots, generating quite a bit of excitement among the students. After observing and discussing this event, students made charts indicating which plants sprouted first, which of the early sprouters showed the most rapid growth, and which locations in the room seemed to favor plant growth.* Plants close to the window (getting direct sunlight) were doing the best, those furthest from the light seemed the worst, and those in between were progressing moderately, the children noted from their charts.

We discussed responsibility. Each person was to be responsible for watering his or her own plants, the class decided, except, of course, in cases of absence. Later in

*The children might draw line graphs of their data. If the horizontal axis shows dates starting with the planting date, the graph will show germination time as well as rate of growth.--ED.

the year, a discussion turned to the topic of watering techniques because some problems had arisen. Some children watered their plants too much; some, not enough; and some, a little over-zealous in their concern for plants, watered other children's plants. The class urged those who underwatered to check their plants daily and those who overwatered to use the spray bottle (a plastic window-cleaner bottle). They reemphasized each person's responsibility for his or her plants, and they put the class plants in the charge of the over-zealous caretakers.

Delight spread through the class one day when one girl's bean plant sprouted its first stringbeans. Earlier, the class had gotten this plant through a crisis by tying the lanky plant to a ruler, which, as one child put it, "helped it to stay straight up and take water better." Up to this point the class had fed our pet guinea pigs plant leaves, but feeding beans to the pets was a real treat for the children (and for the guinea pigs). This success increased the popularity of growing vegetables, and later in the year some plants bore enough food for the children to bring home as contributions to dinner.

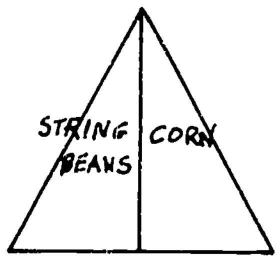
To get more mileage from the enthusiasm generated by the challenge, I incorporated the plant motif into other subjects. For example, the class worked on an art project in which they created three-dimensional plants by drawing oversized carrots, radishes, and other plants and then using strips of construction paper to give the illusion of protruding leaves. The class displayed these works of art in the hall, along with a sign inviting people to come in and see our real plants.

While patiently following the progress of our plants (transplanting when necessary), we initiated a class project--planting a sweet potato. Two children inserted toothpicks into the potato and then, carefully placing it in a tumbler half-filled with water, made sure the toothpicks supported the potato so that one end was submerged in the water. Despite abundant optimism and moral support, nothing sprouted from the sweet potato--even after five weeks. We later learned that most store-bought sweet potatoes are heat-treated to prevent sprouting and that only non-treated sweet potatoes will grow. Later in the year, we repeated the procedure, using another potato. (The vegetable-stand owner said there's no way to tell whether one has been treated.) This grew remarkably well because the potato was untreated, or, perhaps, because this time we had cut off the tip.

As plants outgrew their original containers, the children realized they would need to transplant them into larger

ones. They also wanted to plant more seeds. The children decided that making wooden planters in the Design Lab would answer the needs of their plants and would also add to the attractiveness of the room in line with the challenge.

Plant size, root structure, and the number of plants to be transplanted all played a part in the design of the planters. Given a choice to work individually or in two's, the children chose to work in pairs. Each pair figured out the size of two planters and made detailed plans in preparation for going to the Design Lab. Some children used their rulers to help them decide the dimensions of their planters. Two girls measured the pots in the room to see how much room the roots took up. One boy drew a diagram like this:



T: How many inches is this going to be?
S: All sides are going to be eight inches and there's going to be a board in the center
T: How deep is it going to be?
S: One inch.
T: Is that enough for the dirt? Don't you think the roots are going to take up more than one inch?
S: Yes, maybe it should be about four inches for the sides; three inches for the soil.

In the Design Lab, unexpected assistance from a Science Department member allowed the class to divide into two groups; one worked on the wooden planters and the other made macrame hangers for the planters. Throughout the span of several weeks in which we frequented the lab, students switched groups so that they learned both carpentry and macrame skills. During this period, I took opportunities to bring up issues pertinent to Design Lab work. We reviewed the importance of following safety rules. We also discussed how to deal with discouragement to help the children stick to a project until completion. On both the macrame and wood projects, they persevered, worked hard, cooperated with each other, and thoroughly enjoyed the lab work. Many children eagerly stayed after school hours to

continue working on their projects and some took their work home. (I partially attribute this enthusiasm to the rewards of seeing their planning and hard work lead to a concrete achievement--beautification of their room.)

Children began their macrame projects by examining samples of a basic pattern. They decided to practice that pattern and get it "down pat" before attempting more creative designs. The availability of a book about macrame and twine of varied colors offered opportunity for more advanced patterns. One pair of students used two colors, which not only looked attractive, but allowed the pair to keep track of their knots more easily.

One boy brought in a macrame plant hanger that be made at home and prepared for the class a how-to-do-it chart containing these pointers:

1. Cut eight pieces of yarn a yardstick length.
2. Tie a tight knot at the bottom.
3. Go up four inches from the bottom, divide the yarn into four groups, tie knots making sure all the knots are even across.
4. Go up four inches and take one string from each knot and tie another knot.
5. At the top, tie a knot with a loop in it to hang the hanger.

By the second half of January, the students had completed and painted their planters (thanks to some work at home during the holiday vacation). The planters would help them fulfill the challenge, they agreed. Although anxious to start planting, they decided first to set up work stations. This idea made for much smoother planting sessions--less mess, noise, and confusion.

This time around, children experimented with different plants and different growing media. Having recently learned about mixtures in Science, some children prepared mixtures of pebbles and soil, some placed a layer of soil atop pebbles or sand, some tried vermiculite, and some stuck with pure soil.* Seeds that they planted included marigolds (very popular), beans, corn, oranges, and honeydew.

We also worked with cuttings from some of our larger

*The children might keep records of growth of plants in the three kinds of soils to find out which is best for a certain type of plant.--ED.

plants. The process intrigued the children, many of whom tried it with such plants as Swedish ivy and coleus.

Another intriguing project was developing elsewhere in the room; one girl had mixed potting soil, pebbles, and water in a plastic, egg-shaped bowl (about seven inches in diameter) to make a terrarium. She placed leaves and small cuttings upon the soil mixture, added a bit more water, and put the terrarium in a more shaded area of the room. This child had done some earlier research that included a visit to a teacher who had a terrarium. Several members of the class adopted the terrarium as a pet project, and later in the year, when children in other classes worked on terrarium projects, they came to our class for ideas and assistance.

With their new crop of pots and planters, the class discussed where to put all of it. Because most of the planters turned out large and heavy, only a few proved suitable for hanging. The heavy ones would serve as window boxes, the class decided. (To protect the planters from the night chill near the windows, the children painstakingly moved them to a table or desk at the end of each school day.) Proud of the new arrangement, the class felt they were meeting the challenge. Several teachers agreed (much to the students' pleasure) that the room looked great.

As another class project, we tried our luck with avocados. We used toothpicks to suspend an avocado seed in each of two tumblers of water and placed the tumblers away from direct light. The children viewed a picture showing a seed sprouting roots and one showing the growing plant. Naturally, the children expected such growth to occur in one day. After several weeks, one seed seemed to rot, the other did nothing. One girl, who had three avocados growing at home, suggested throwing out the bad seed and saving the good one. After the seed showed no progress for the next two weeks, we followed a student's suggestion and put the seed in total darkness--no improvement. We remembered that the seeds had been accidentally submerged in water several times and to these occurances we attributed the failure of the seeds to grow.

In contrast, we fared much better with peanuts, despite an initial setback. We had planted two unroasted peanuts in accordance (I thought) with instructions in a kit, but I had misinterpreted the directions and did not shell the peanuts. Our next attempt proved successful. Following directions, we used red yarn instead of soil for the growing medium. One peanut, planted in a covered plastic container provided with the kit, grew remarkably fast. Another, planted in a milk carton, made slower progress, but it grew.

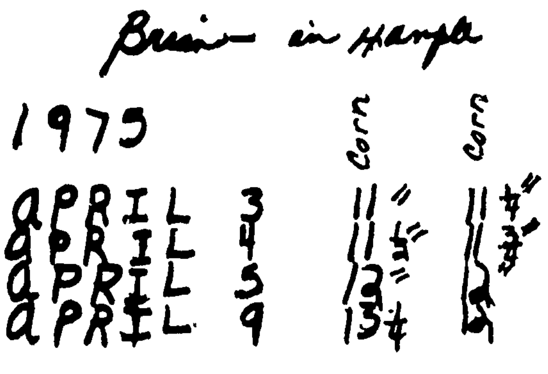


Figure C1-2

When the stronger plant outgrew its container, we transplanted it into a planter in this way: we filled a one-inch-deep hole with water, inserted the plant (including the red yarn), and put mud around the roots. We switched the less fortunate plant from its milk carton to the vacant plastic container. Although this weaker plant flourished for a while after this change, it eventually died soon after we discovered it positioned upside down in its container. However, the hardier plant adapted well to its roomier situation and grew by leaps and bounds.

Several days before winter recess, the children discussed what to do with their plants during the upcoming vacation. They decided to take a few plants home and leave the remaining ones in a single area of the room, with the hope that the custodians would do the watering chores in our absence.

The vacation resulted in relatively few casualties. On the way home, one student had dropped a planter, killing the plants in that container. Cold weather had made most of the children extremely careful with the plants they carried home. These plants returned in fine shape. The class readily revitalized the plants they had left in their classroom. (Months later, when spring recess came, the children decided to take all their plants home for the week.)

To record the progress of their plants, children periodically measured and wrote down plant height (see Figure C1-2). Some children drew pictures of their plants at various times in a qualitative pictorial bar graph. (See Figure C1-3). Most plants grew successfully.

Failing plants gave children a chance to practice other analytical skills. Students continually engaged in trouble-shooting, trying to figure out why some plants (their own, other students', or class plants) didn't grow properly. Usually they were bursting with suggestions for improving the health of ill or nongrowing plants. For example, when some leaves in the terrarium exhibited blackened edges, some students suspected insufficient water and too much sun. They checked the soil, found it very dry, and recommended adding water.

Overcrowding was the most common problem and proved fatal to some plants. (This problem didn't occur in the planters, which the children had made sufficiently large.) Eventually, the children learned to avert disaster by thinning out their pots and transplanting when necessary. But this solution did not apply to vegetables, particularly corn, which was ready to be transplanted outdoors by early April. Unfor-

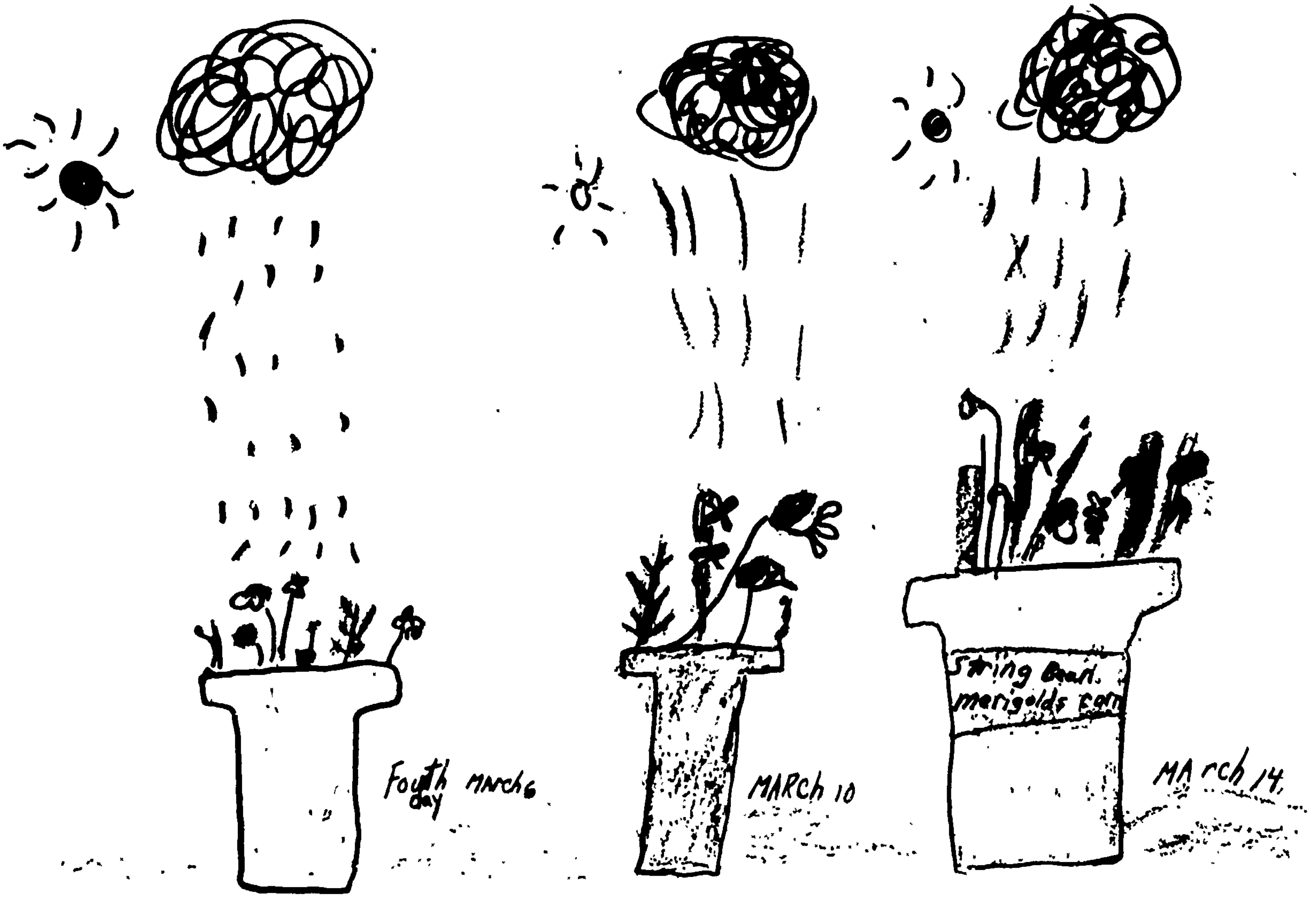


Figure C1-3

tunately, the ground had not completely thawed. The children recommended that in the future they should plant vegetables later in the year to prevent transplanting problems.

Despite these problems, most plants flourished and the selection in the room grew more varied as the year progressed. One child brought in pussy willows. Another introduced the class to cotton seeds and showed students how to pull the seeds free of the cotton boll for planting. One boy

carried in a one-year-old locust tree that he and his father had grown from a seed. A coffee tree that we had sent away for became a class plant.

Flourishing, too, was the attitude of the class. The enthusiasm generated by the unit reached to the students' homes, where the children began growing plants for bookshelves, etc. At conferences and PTA meetings, parents commented very favorably on their children's interest in plants. Parents were particularly surprised at how aware the children were of the actual challenge--considering that the class had worked on the unit since the beginning of the school year. Our excitement about plants even bubbled over to the two other third-grade classes, which began growing plants in school--with good results and much enjoyment.

The abundance of plant life in our room sparked an internal controversy over plant placement. One group of students felt that we should spread the plants throughout our room to provide the most attractive appearance. Other students felt we should locate all the plants in one area because the plants took up a lot of room (and table space) that we could put to better use. They believed we could retain the beauty and charm of the greenery without sacrificing so much space. During the discussion, I noticed that the children responded to each other's ideas--they didn't just offer isolated comments.

The class finally settled on a compromise. They decided to keep the hanging plants located throughout the room, but they would try to build shelves so that they could place the nonhanging plants in a single area. Breaking into groups, the children tried to design shelves that would hold many plants, yet use a minimum of space. Groups presented their designs to the class, which then chose the best one. Then a small group of students went to the Design Lab to begin construction. (By this time the school had obtained a full-time Design Lab manager, enabling unescorted groups to work in the lab, provided they had a plan of action.) The construction grew into a class project, but students basically adhered to the original design. The school year ended before they had completed the shelves, but, as the children wisely pointed out, at least they had the fun of thinking up the idea.

Not only did the students meet the original challenge of beautifying our classroom, but in the process, I felt that they also--

1. enhanced the appearance of their homes
2. became more aware of nature

3. improved their abilities to communicate ideas and to listen and respond to the ideas of others
4. provided food, and
5. learned useful skills ranging from mathematics to gardening.

2. LOG ON GROWING PLANTS

by Peter Schiot*
Oyster River School, Grade 5
Durham, NH
(February 1975-June 1975)

ABSTRACT

The twenty-five children in this fifth-grade class at the Oyster River School in Durham, New Hampshire, worked on the Growing Plants challenge enthusiastically for sixteen or more hours a week during the second half of the school year. The children decided on a challenge of growing food for poor people and flowers for residents at a nursing home. With the help of several parents they constructed a greenhouse for growing plants in the classroom out of wood and plastic sheeting. Working in groups that shifted frequently, the children scrounged and bought soil, pots, macrame twine for plant hangers, and seeds. They planted seeds of many different varieties and grew the young plants in the greenhouse. The children made their own potting soil from peat moss and sludge from a sewage treatment plant. They also tested soils for pH and mineral content and researched ways to improve soil for growing plants by adding organic materials such as weed ashes or bonemeal. They used the University of New Hampshire library and greenhouses extensively for finding out agricultural information. When the mother of one child offered the use of a plot of land for a garden, the children cleared the land and transplanted many of the greenhouse plants to the garden. They also held an Open House to provide information to other classes and to demonstrate techniques of composting, soil testing, germination, transplanting, and caring for plants. The children sold many plants and hangers to other children. After the Open House, the teacher asked the children what had happened to the original challenge, and the class decided to take vegetable and flower plants to the home for the aged before the school year ended.

My class began by discussing food both for animals and for people. The students became so enthusiastic about

*Edited by USMES staff

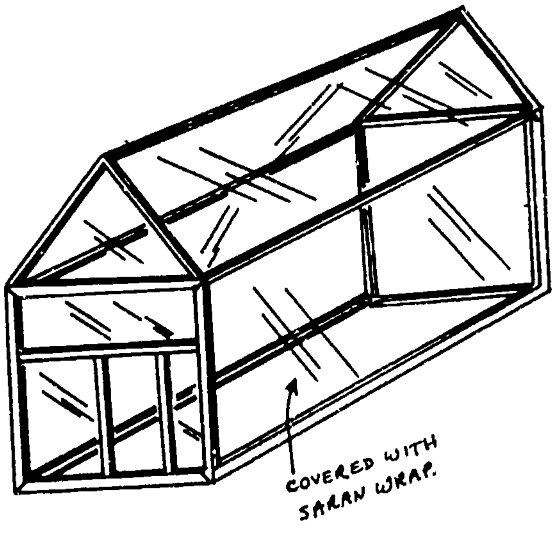


Figure C2-1

the challenge that they worked sixteen or more hours a week growing plants in the classroom.

During most of the school year, we had kept animals in the classroom. The children had collected seeds and left-overs from the cafeteria to feed the animals, but I still felt that they were not taking care of them properly. During one of the numerous conversations we had on finding better ways of caring for the animals, one child suggested that we grow food for the animals. However, the children had recently seen a film on the food shortage in India (made by one of the oil companies advertising fertilizer) and were very sensitive to human needs for healthy food and a good diet. One child immediately retorted "Why grow food for animals, why not grow food for poor people?" Everyone agreed, and the class enthusiastically decided that they would try to grow food for poor people. In a later discussion, they also decided to grow flowers for a home for the aged where they had recently put on a Christmas program.

During February and March, the class spent more time on USMES than on regular classwork. After February vacation, the children initiated a discussion about how they could grow their plants. They came up with the idea of building a greenhouse in the classroom. One child suggested that we have a contest to see who could design the best greenhouse. During the next few days, children in the class built eight models, designed several greenhouses on paper, and brought in plans taken from 4H Club bulletin, Better Homes and Gardens, and the U.S. Department of Agriculture Bulletin #357. We had a brief talk about each design, particularly the ones drawn on paper. Several children had difficulty showing a three-dimensional model on paper and wanted to know how architects made their plans. I felt that a skill session on scale drawings was necessary, and we spent several hours making drawings of various things to scale on graph paper. Later, we went to the University of New Hampshire Library, and eight to ten of the children in the class took out books on greenhouse design, plants, flowers, and other agricultural topics.

Another class judged the models and drawings made by children in our class. The model which was chosen as the best was then used to design the greenhouse; the only changes made were the addition of studs and angles as braces for the building. A drawing of the model is shown in Figure C2-1.

I held a meeting with several parents of the children in my class to find out if they could help scrounge materials

for building the greenhouse. The head of the Science Department, who also came to this meeting, was very enthusiastic about the greenhouse and donated a set of fluorescent lights. After the children had selected a model for the greenhouse, we held a parent/children meeting one evening to discuss finances and other planning problems. Approximately twenty children showed up with their parents. During the course of the evening it was apparent that the children had called every lumber mill and supply house in the area to obtain costs of supplies. We felt that these evening information meetings were useful for both parents and children and decided that we should have one every week for a while.

The following day we began figuring out the size of the greenhouse, the amount of materials, and building costs. In a class discussion we considered the difference between the construction cost if we had the greenhouse built for the class versus the cost of doing it ourselves, which would include only the cost of materials. We also talked about what materials could be acquired for free. The children obtained complete estimates from lumber mills and in the process became familiar with building lingo; words such as two-by-four, studs, and board feet became an important part of their vocabulary.

During a class discussion the following week, the children decided that building materials could be bought at the lowest prices at the Diamond National lumber supply house. It seemed that at least half the class had called this place, since several children quoted the price of 69¢ for a 2" x 4" x 8'.

Our next task was to figure out how much of each material to order. We divided into groups to figure out how much wood, plastic, tools, and other materials were needed.

Meanwhile, some of the children had begun to grow their own seeds without waiting for the greenhouse to be built. They were asking me all kinds of gardening questions, many of which I could not answer. I took several children to the University of New Hampshire greenhouse so that we could learn more about techniques for growing plants. One of the children invited a technician to come to our Monday night session with parents. The following Monday, twenty parents, twenty-two children, and the technician, whose name was Frank Mitchell, showed up for our weekly meeting. Frank gave a lot of general information on gardening and suggested several points which impressed the children:

1. Get started; don't worry about making mistakes.
2. Plan your garden on paper.
3. Use biological controls, not chemicals, to keep down number of insects (e.g., Bacillus thuringiensis, sold commercially as Biotrol, which attacks the cabbage worm but will not harm other animals).
4. Plant to conserve space (e.g., pole beans take up less room than beans in rows).

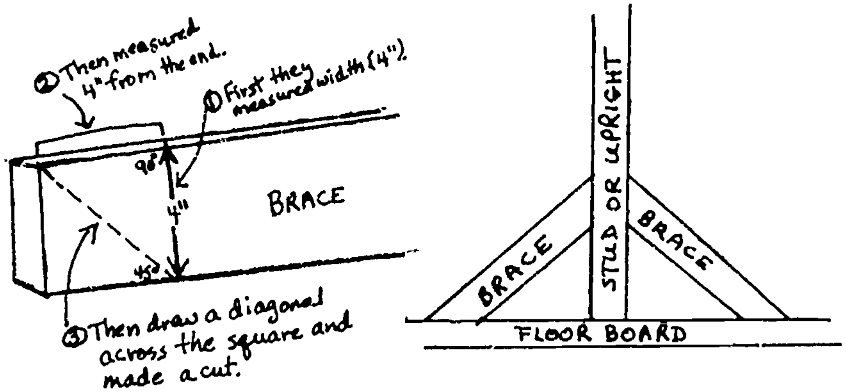
The following day, our room was like Grand Central Station. Everyone had brought in books, magazine articles, plants, seeds, etc. Children started plants such as radishes, carrots, and corn on the window sill by potting them in boxes or milk cartons with soil from the school grounds. Around noontime our lumber arrived. The delivery men became interested in our greenhouse and told the children how wood was measured, graded (ours was "construction grade"), dried, and stored. The children detained the men for almost an hour.

That evening, parents and children began arriving at 6:00 to begin constructing the greenhouse. We had an abundance of labor and tools for the project. Following the original plan for the greenhouse, we started to build a structure which was eight feet wide and twelve feet long. The greenhouse was constructed in the northeast corner of the classroom, where it would receive the most sunlight. Parents and children split into groups to measure boards, estimate amounts of plastic sheeting for the sides, saw wood, or nail boards together. The parents were anxious to help, but they wanted to do too much of the job, and I reminded them that the children should do as much as possible themselves. By the end of the evening, we had the floor laid out and the sides and uprights nailed on and braced temporarily.

The following morning, several children who had not been present during the evening building session asked if they could help work on the greenhouse. The children figured out a way to fasten a brace to either side of each upright or stud. The trickiest part was making a diagonal cut in each end of the brace. They found that the brace was 4" across, then measured 4" from the end of the board and drew a line across, making it a square. They drew a diagonal across the square and cut along it, making an isosceles right triangle. When they did this to both ends, they could

fit the brace between the floor frame and the upright. A diagram of this is shown in Figure C2-2.

Figure C2-2



We continued building in the evening. This time the children did most of the work, and the parents lent support only when needed. Building the roof presented a problem during this session, however; a parent who was a builder told the children how to use a "ridge pole" as the main support of the roof and how to figure out how much of a slope the roof should have. He said that in the olden days, neighbors would help a family to lay out a roof for their house or barn, and then everyone would help raise it together. The children decided to do this; all went smoothly with everyone's cooperation.

Early the next morning the children made measurements for the door, and a crew of four children began to work on building it. The group examined the construction of several doors in the school building and finally decided to design their own. They built a frame which they covered with plastic sheeting and attached to the doorway with hinges. A diagram showing the design of the door is given in Figure C2-3.

While the door was being constructed, another group of children began covering the greenhouse with plastic sheeting. We had obtained some plastic sheeting from a lumber supply company which used it to cover piles of wood; this material was somewhat dirty, and we used it for covering the sides. The children cut out and measured the plastic for each section of the house. They placed one 13' x 10' piece of cleaner plastic over the roof, tacked it to the roof struts, and cut off the excess plastic. One boy brought in plastic stripping which is used in nurseries to fasten the plastic to wood. This provided a strong seal

and also prevented the plastic from ripping on the nails. (The children tried to use staple guns, but they were not strong enough to secure the staples effectively. The greenhouse was completed except for the lights, which were added within the next few days. The children scrounged three sets of fluorescent lights from public buildings that were being torn down.

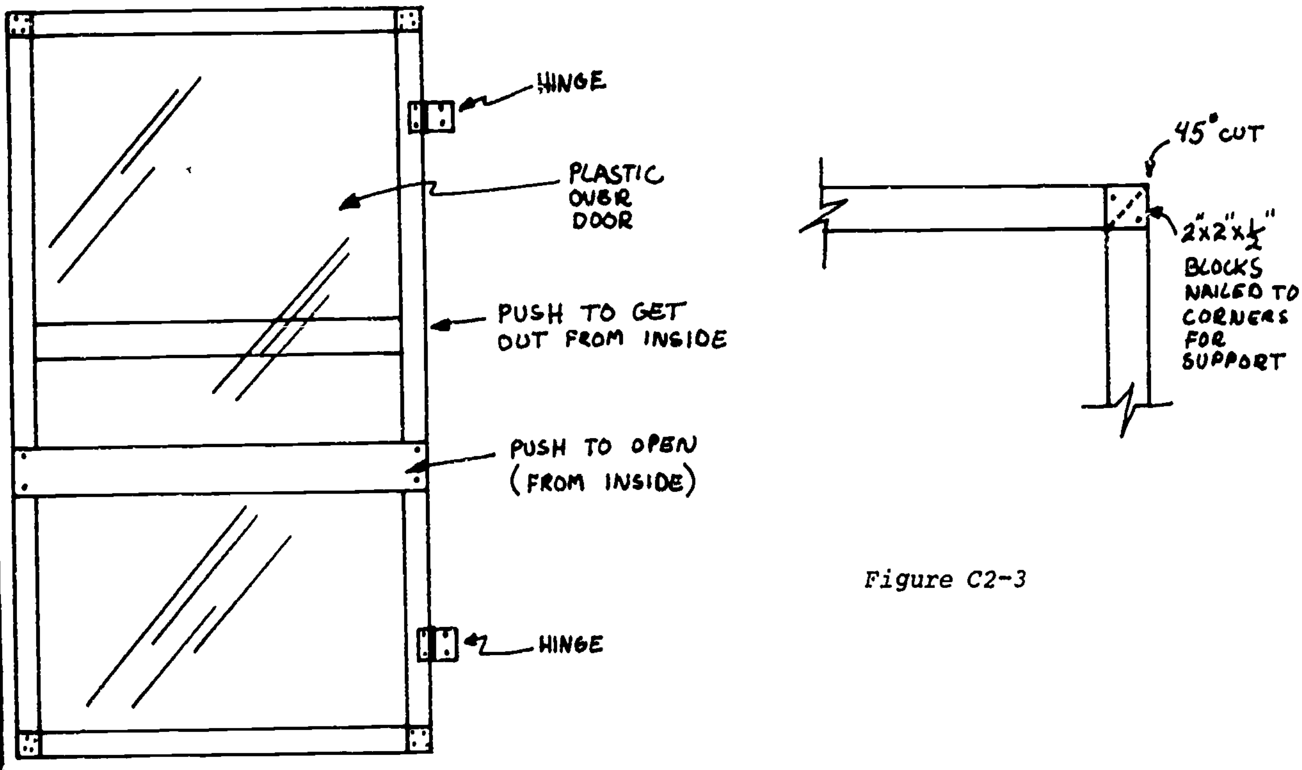


Figure C2-3

The father of one of the boys in the class was a biologist at University of New Hampshire, and he asked if he could give the children a few tips on soil. He brought in some garden soil and showed the children how to test soil for pH.* He added various quantities of baking soda to each sample and showed how it changed the color of "Pan Peha" litmus paper used for testing. (Since baking soda is alkaline, it would raise the pH of the soil depending on how much was added to each sample. He explained what he had

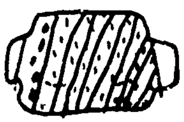
*A definition of pH may be found in the Glossary, Section 4 of this book.--ED.

germination test

DAVID Z.

first you take 10 or 100 seeds its best to use 100 seeds then you take a paper towel and put it in a dish then you put the seeds on the paper towel and put water so the paper towel is wet then you put seran wrap over the top the water when need to

ever seed Germinates equals one per cent Germinaten



I used a dish somthing like this one

Figure C2-4

done and told the children that their soil at home would all show different pH factors. The children were fascinated and went outside to gather soil samples from the playground. When they returned, they mixed each sample with water and tested it with six colors of litmus paper. Each color turned a shade of the original hue, which was then matched on a chart of twenty-five colors corresponding with pH values ranging from 2.0 to 14.0. The children discovered that their sample ranged from pH 4.5 (under pine trees) to 7.5.

As a result of this session, children brought in soil samples from home to test. They also developed the idea of testing samples for others for free to obtain more experience.

During the following week, the children began growing plants in earnest. They brought in seeds of all kinds to germinate. Children with expertise emerged as various group leaders. One boy who had learned about planting from the Boy Scouts showed eight other children how to run germination tests to see what percentage of seeds that were planted germinated. One child's explanation of the germination test is shown in Figure C2-4. This test was useful because some of the seeds the children were using were from previous years, and they needed to know how good the seeds were before planting them in large numbers. The children found that one-year-old seeds were as good as new ones. When they ran a test on seeds older than one year, they found that only thirty per cent of the seeds sprouted and concluded that these seeds were no good.*

The children also investigated soil test kits which would be easier to use than the one suggested by the soil expert. They discovered that the simplest kit was produced by Perfect Garden Company (15 E. 46th St., New York, N.Y.). The advantage of this kit was that it required matching fewer colors (red-green) for a pH range of .4 - 9 and cost only $1.29/100 ft. litmus paper.

The Monday evening sessions with parents were turning out to be so beneficial that the children wanted to bring in more speakers. The children and I made several calls to neighborhood garden experts and to other people who knew about plants. The next session was on macrame. Several

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*The children might draw bar graphs of the germination rates for the seeds of different ages. The results for different types of seeds might be shown on one graph by using lines instead of bars. (See "How To" Cards.) --ED.

parents and children showed up to learn different ways of tying knots for making hangers for plants. Six people, including students and people from the community, led this session, which produced several nice-looking hangers. The children were enthusiastic about having hanging plants both in the classroom and at home. They decided to find a way to get free twine for their efforts. A few days later, three girls mysteriously told me to drive them to the home of a woman whose husband worked in a manufacturing company which used twine. The children found out later that the company used the twine for wrapping the inside wires of transatlantic cable. Whenever the twine broke, the spools were taken off and the excess twine thrown away. The twine had been water-proofed to prevent rotting. We received twenty partially-used spools of thrown-away twine. The girls calculated that it took six pieces of twine each six yards long to make a hanger for a plant. Since each spool contained enough for six to fourteen hangers, we had enough twine for at least 150 pots.

Another speaker invited by the children had other helpful suggestions on other ways to save money. She suggested that the children check prices at a seed company called Visey on Prince Edward Island. A child in the class who had been working on a report about Prince Edward Island said that the climate was similar to ours so that the seeds would probably be hardy. The children examined the catalog from the company and discovered that seeds were much cheaper than at other companies.

The children were aware that with all our activities outside and in the greenhouse, we needed to make some rules. I received many suggestions about rules, but I turned the problem over to the children. The class held its own meeting and listed the following rules to be enacted:

No foolin' around in the greenhouse.
No throwin' stuff.
No pushing.
Job assignments are to be made - floors swept, and washed every day.
No buggin' people workin'.
Tables are to be kept clean.
Dirt and soil should be thrown in one box.
No leaving snacks and baggies in the greenhouse.

A few days later the children realized that they needed some kind of potting soil to germinate seeds. The New

England clay soil cracked horribly and did not produce healthy plants. We took another trip to the U.N.H. library to pick up books on potting soil. We also went to Agway, our local farm and garden supply store. Besides potting soil, the children decided we needed peat pots for planting, fertilizer, and nasturtium and marigold seeds to be planted as a guard against bugs (an idea that came from a speaker who suggested organic methods of insect control). We bought 100 pots at 4¢/pot and spent $3.98 for soil, $1.95 for fertilizer, and $3.90 for seeds.

At the children's request, the speaker for the following Monday evening session was again Frank Mitchell, the greenhouse technician from U.N.H. After describing basic plant needs such as air, water, and light, he concentrated on the "growing medium." The children asked questions about how potting soil was made. Various soil "recipes" were exchanged, and ways of sterilizing soil by homogenizing or heating it were discussed. Frank showed us how to make a compost pile from leaves, straw, soil, vegetable scraps we had already collected from other classes, and manure donated by one of the girls' cows. We started our compost pile in a huge waste basket and kept it in the classroom. I checked the temperature each day to see how fast it was decomposing, but the children seemed to forget about it after a while.

A free bulletin called the 1974 Vegetable Variety Guide (from Cooperative Extension Service, Department of Plant Science, U.N.H., Durham, N. H.) created a lot of excitement for the children. The guide listed varieties of vegetables having the best yield, the most disease resistance, hardiness, etc. It also listed plants that grow well together (companion planting) or after other plants have been harvested (successive plantings). At an "open house" at the University of New Hampshire greenhouses, the children observed several experiments in progress to compare growing media, pH levels, and lighting conditions for plants. The children were filled with a virtually limitless supply of ideas on what plants to grow and how to grow them.

The children began planting once again, using egg cartons for germinating seeds of all types. They cut tags out of milk cartons to label each plant. They brought in seeds of all kinds to be planted. I noticed avocado, grapefruit, and even wild seeds which they wanted to identify. Children swapped seeds back and forth; anyone who had brought something new was somewhat of a hero. The influx of "mystery" seeds and plants increased as children began digging up weeds

to find out what they were. When several boxes of seeds and weeds were brought into the greenhouse, the children who were testing soil and planting vegetables and flowers objected strongly, because they didn't want their domestic plants to be contaminated. So the people with the mystery plants made small hothouses at their desks with baggies and plastic covers from the cleaners.

Several students continued their research on the pH of soil. The children discovered a large body of free literature put out by the Cooperative Extension Service of U.N.H. including a pamphlet listing the pH preferences of common plants. The list of vegetables and their pH preferences made by the children is shown in Figure C2-5. The children read in a book that adding various quantities of wood ash would raise the pH to the preferred level. They made posters asking for donations of wood ashes.

The student who had shown other children how to determine per cent germination of seeds demonstrated to another group how to run an experiment on the effects of too much acidity on red cabbage. They planted red cabbage seedlings in three different kinds of soil: (1) soil to which pine needles had been added with a pH of 5.0, (2) ordinary garden soil with a pH of 6.0, and (3) soil to which wood ashes had been added with a pH of 7.0. By observing the plants, the children learned that cabbage grows best in soil with a neutral pH of about 7.0 (higher than most garden soils) and that it grows worst in acidic conditions (pH 5.0).*

A second drive to improve the potting soil used for planting was mounted by a small group of students. This group began encouraging other children to get rid of any plant that looked unhealthy. The four children in the group made another trip to Agway to buy more potting soil. They asked the salespeople and the manager many questions about soil including why it cost so much. The manager replied that it had to be heated to 150° and then mixed with peat moss and perlite. On the way back to school, the children decided that we could make our own soil. We had bought a small bag of peat moss to use for mixing. The children

PH 4to6
Peanut
Potato
Radish

PH around 7
Pumpkin
Rice
TUrniP

PH around 8 but not above
AS Paragus
Bean
Beat
cabbage
cauliflower
celery
cucumber
Lettuce
Onion
Parsnip
Pea
Rhubarb
Squash

Figure C2-5

*The children might measure the growth of the plants and make a line graph of the average of the data from the seedlings grown under one condition. A composite graph can also be made showing data from plants grown under different conditions. Finally, a line graph showing the effects on growth of different pH's after a certain time period should be drawn.--ED.

decided to work on this later and began planting some seeds that they had bought.

When several students came to me the next day to ask how to get rocks out of the soil they were digging up, I decided to help them out by explaining more about the compost pile in the room. I hoped that they would realize that there were alternatives to the New England "clay" for potting soil. (Several students in the class had already helped me load manure from a local cow barn for my own compost pile.) I pulled out our compost bin, and we examined the material. It was hot, ordorless, and well-decomposed. The children were amazed to find apple cores and banana peels nearly disintegrated. They invited the principal in to look at the material and describe it. Had he known before that we had a compost pile in the classroom, he would have been aghast; however, both he and the school nurses, whom he called in immediately, were impressed by the compost. The children were interested in the compost, but they felt it would take too long to make to be of much use for potting soil. Once again, they tried to think of a quick way to obtain a large supply of something that was better than "the junk out front." They thought of using sand, but a bus driver told them that sources near the school were loaded with salt.

The children asked the woman who had given them tips on organic gardening if she knew where they could get good soil for potting plants. She suggested that they ask the Durham Sewage Treatment Plant for free sludge. The children didn't understand what sludge was, but after talking to the plant manager they realized that it was like gold to gardeners. He offered to give the children a tour of the plant, and I took four children over in the afternoon. The children were fascinated by the plant. In one room workers were screening five-year old deactivated sludge. The group asked numerous questions about the sludge and the sewage treatment process. We left with a load of sludge, and the children decided to get the other children to try to guess what it was. Back at school, the children brought sackloads of sludge into the classroom and began mixing it with peat, peat and vermiculite, peat and perlite, or other combinations. After growing plants in several of these media, they finally arrived at the conclusion that a potting soil of 1/3 peat moss and 2/3 deactivated sludge made a healthy and inexpensive growing medium for their plants.*

The following day I took another group of students to the sewage treatment plant. This time a wind was blowing the

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*[illegible]otnote on previous page.

aroma of the fresh sludge in our direction, and the children were overpowered by the smell. They had strong doubts about the sludge, but after talking to the workers they were reassured that the five-year-old deactivated mixture they received was not a health hazard. On the way back to school some of the students suggested selling the mixture, but one student stepped in and said that we needed it all to pot our plants.

The children continued to devise their own methods of planting and caring for the plants. One interesting discussion arose concerning the best way to germinate seeds in a cardboard egg carton: by using the bottom half which is subdivided into twelve cups or the top half which is not. Some children objected to the ridges, which they felt took up too much space. Others felt that no more than twelve of some kinds of plants could grow comfortably in an egg carton anyway. One student suggested that the little cups could be cut out and placed directly in the ground (like a peat pot), making transplanting unnecessary. But another student added that holes would have to be punched in them so that air and water could go through.

I noticed that the children were using a strange variety of containers to water their plants; these included jars, liquid soap bottles, and even squirt guns.

Once the soil problem was solved, the children had to figure out what other factors were causing ill health in their plants. Some of the earlier plants were leggy, especially the lettuce. The plastic walls of the greenhouse trapped heat inside and made the temperature much higher than the rest of the room. One student read that heat was bad for lettuce and some other kinds of plants and felt that this might be causing the wilting problem. We felt that it might not be feasible to grow healthy lettuce in the greenhouse environment. Some children also felt that the plants might not be receiving enough light since (1) the flourescent lights were on only during school hours (2) the children sitting near the greenhouse left the shades down overnight, thereby depriving the plants of sunlight from sunrise until we arrived at 8:30 a.m.* The children also suggested that overwatering of plants was a problem. Another criticism was that people who planted seeds in egg carton did not put enough soil in the bottom of each cup. The roots grew into the cardboard, making it impossible to remove the seed-

*The children might take measurements of growth under various lighting conditions and make graphs to show the results.--ED.

lings without damaging them. After this discussion we worked for two hours trying to correct these problems.

One boy in our class arranged a field trip to his grandfather's rose farm. The boy and his grandfather pointed out how the roses were started, cut, packed, and shipped. They pointed out the different varieties of roses in the mile-long greenhouse. The children were curious about the construction of the greenhouse. They asked questions about the maintenance of the greenhouse, the use of mulch piles, and even the patenting of various rose types. The children were given roses and cuttings of stephanotis (a tropical woody vine). They asked for tips on rooting vines and received some helpful information from the boy's grandfather.

We had another class discussion on the use of fertilizers for plants. One boy had brought some manure home to put on his mother's plants, and they had died! Another child had a good response to this: "What do you expect if our compost pile gets up to 130°?" We decided that it was not a good idea to use manure by itself. We also examined our compost pile and saw that it had turned into a rich mixture of dark brown humus. We decided that it was time to bury it temporarily out front under the area from which we had taken our "clay" soil. We added bags of vegetable scraps and manure to the compost and covered the mixture with soil (to hide it). Later, the children decided to donate the pile to another teacher who was making a garden.

Mrs. Nevin, our organic gardening "expert," offered the children a piece of land on her property to help them get rid of their extra seedlings. The children were very enthusiastic about the idea of having their own garden. Many of them had been bringing their plants home because they were very proud of their accomplishments and wanted to share their experiences with their parents. Almost everyone had made their own gardens at home from transplanted vegetables and flowers, but the idea of a class garden caught on like wildfire. I took four children on another trip to Agway to investigate seeds which could be put into the ground immediately. An hour later we left the store with pea (Progress #9 and Snow), Black-seeded Simpson lettuce, carrot, brussel sprout, and (early) broccoli seeds, as well as in additional supply of peat moss and "Jiffy" peat pots. (One girl discovered that we had paid $2.09 for one cubic yard of peat, while six cubic yards cost $6.95. If peat were purchased in single cubic yards, then six would cost $12.54. "This is outrageous!" she said. The other kids agreed that people who purchased in small quantities were "ripped off." She began

calculating the difference between the cost of potting soil which was purchased and soil which they made themselves. She said that she wanted to sell potting soil at cost.)

When the Nevins' garden had been cleared for us, we went over to inspect the area which is about 3/4 mile from the school. Our patch of land was approximately 50' x 25', high, woody, and full of rocks and boulders. The horses which had been pastured there had been removed and a tractor had turned over the ground, but that was all. We would have to clear it ourselves. We went back to school and held a class discussion about our "plan of attack." The children divided into groups to gather garden tools and to research directions for outside planting.

Two days later, we left for the garden early in the morning. On the way over, the children compared their tools and discussed the usage of each. We passed a man who was rototilling another field. The children were interested in the machine and tried to convince the man to come up to our little patch. However, he said that we had work to do which his rototiller could not handle.

The children began raking, hoeing, digging, and pulling weeds. They organized themselves in groups and tried to schedule their tasks so that they were not in one another's way. One group started a compost pile by measuring five feet of fence, cutting it, and nailing it to a tree. They squared off the area around it and were ready to fill it in. Meanwhile, another group was gathering materials around the area to put in the pile. They offered to rake the paddocks and sweep the stalls where the horses were kept to obtain manure and to collect old grass and leaves.

Another group began ripping roots out of the ground in the cleared area. They developed a system of pulling on big roots together, and when they could pull no more, they cut the roots with spades. A group of children tried to remove the boulders, but some of them were too heavy. One resourceful person found an old timber, put the end under a big rock, and pried. They were amazed that they could move 200 to 300 pound stones with the lever they had devised.

We completed that afternoon by spreading composted manure and eight pounds of lime on the garden. The following day, the students continued removing roots and small stones. About six boys began building a stone wall from the numerous rocks removed from the ground. I overheard comments like "The poor pilgrims really had it rough!" or "Farmers must really work hard!"

The next day we went to the garden to plant. The children brought seeds, onions which had sprouted, our potatoes

which had grown beautifully in the greenhouse, and other vegetables to transplant. The children measured off fourteen rows for planting and decided among themselves who would plant each one.* The garden was planted and watered and new manure was added to our compost bin.

When we visited our garden after spring vacation, the children were amazed to see how well everything had grown. The radishes had sprouted along with other kinds of plants. These proved to be weeds which had not been completely removed and which had sprouted new growth. The children began pulling the weeds out. In the process, they discovered new objects of fascination: garden insects and larvae. These treasures were brought back to the classroom to be identified. A new discussion arose: "Kill it!" "No, don't kill it! It might be a good bug!" We decided to find out what everything was before we would consider it harmful to the plants.

Many of the children began making little homes for their insects so that they could watch how they lived and what they ate. All kinds of contraptions, such as milk cartons and cups, were used for homes. Some of the plants which were not in good condition were placed in their cages for them to eat. One of the most popular insects was identified as a wire worm, the larva of the click beetle. Some children also kept earthworms as pets.

In spite of their interest in the garden, the children continued to grow plants in the greenhouse. They were amazed at how well they could grow plants indoors. Several bean plants were producing large string beans, and one boy's potato plants were large and healthy. One child knew to make a wooden trellis for the beans and taught a group of five or six children using cardboard as a model.

Several children thought that it would be fun to invite another class to see the greenhouse. This promptly led to "Let's invite all the classes," which then became "Let's have a plant fair!"

I turned the organization of the fair over to the children. As with other class discussions, I asked a volunteer to chair the discussion. This seemed to lead to more participation than if I had led the discussion. However, the children did have some trouble at first focusing on the subject of the fair. The class became bogged down in spe-

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*The children might plan their garden ahead of time by figuring the space needed for the desired output of each vegetable and the best arrangement of vegetables in the garden [illegible]m to receive the maximum amount of sun. --ED.

cifics such as whom to invite and whom not to invite. The chairman closed the discussion with the suggestion that they needed to think more about the fair and how each individual should participate.

The following week, the students began planning for the fair again. Two boys asked to be permanent chairmen for planning the fair, which was now called an "open house." When the children again began discussing whom they would invite, the chairman neatly channelled the discussion to "who wanted to do what." First, the class decided that people could work either as individuals or in groups. Then they listed several possibilities for demonstration projects: soil testing, macrame, transplanting, starting seeds, greenhouse tour, or making compost. People stated their preferences and everyone was included in a group. The groups split up to decided what they needed to do before the Open House.

During the next class discussion, the children again brought up the question of whom to invite. This time, however, they realized that a great deal of time was needed to give an adequate performance, and they could only choose four classes to bring in. The class voted on which classes should be invited and sent out invitations to the top four. They continued their group preparations for the Open House.

The macrame group obtained more twine for macrame from their free source. The greenhouse group listed the advantages of keeping a greenhouse so that they could tell children during a tour; they also asked each person in the class to submit at least one plant, labelled by name, variety, and date started, so that we would have more plants in the greenhouse. The seed starting groups got plants ready to demonstrate how to plant seeds.

The group testing soils was now eager to obtain all the testing equipment. In the classroom I had kept a soil test kit (from Sudbury Lab, Sudbury, Mass.) that was useful for testing soil for pH and the basic plant nutrients: phosphorous, potassium, and nitrogen. Until this time, it had aroused little interest except when one girl asked me if I could help her test some soil from the District of Columbia. The six children in the soil test group wanted to test our potting soil for nutrients. They tested for pH, nitrogen, phosphorous, and potash (potassium) by adding chemical to the soil, waiting a few minutes, and then matching the color each sample turned to a shade on a chart. The chart for the pH test indicated pH of the soil; charts for each nutrient test indicated by how much the soil was lacking in the particular nutrient expressed in per cent deficiency. When the children tested their potting soil, made from sludge and

peat moss, they found that it had a pH of about 6 1/2, which is nearly ideal for many plants. They also found that their soil was no more than 2% deficient in any of the three basic nutrients. These results confirmed their belief that their soil was quite good for growing plants. When they tested several commercial potting soils, they found that some were seriously lacking in nitrogen.

The soil testing group also called the poison center in Hanover to find out what to do if someone swallowed one of the chemicals in the test kit. When they weren't given the information they needed, they asked the school nurse to call the lab in Sudbury to obtain the information. They also called the U.N.H. greenhouse to find organic methods of correcting nutrient deficiencies in soil, such as adding bone meal or wood ashes.

On the day of the Open House, all of the children came in early with their parents to set up their booths. The children worked hard and cooperated with each other in making preparations:

"What are you doing?"
"Setting up a compost demonstration."
"Let me use some of your wood mulch to demonstrate my test for acid soil."
"Sure, can I have some of your ashes and leaves?"
"Yup."

The first class came in at 9:30. The half hour which followed was really rough. The crew did not seem too sure of themselves. I had decided not to help out or give advice while they were talking to other classes. I felt like stepping in many times, but I saw that they would have to learn from experience. After the other class left, I brought brought our class together to discuss the presentations and how things could be improved. Here is a brief account of their comments.

Compost group - "I put everything-ashes, leaves, garbage manure-in the waste basket, and no one stopped to look."
"Next time, I'll put each thing on a piece of paper, label it, and then show them the finished product."
(Figure C2-6 shows how the compost demonstration was then set up.)

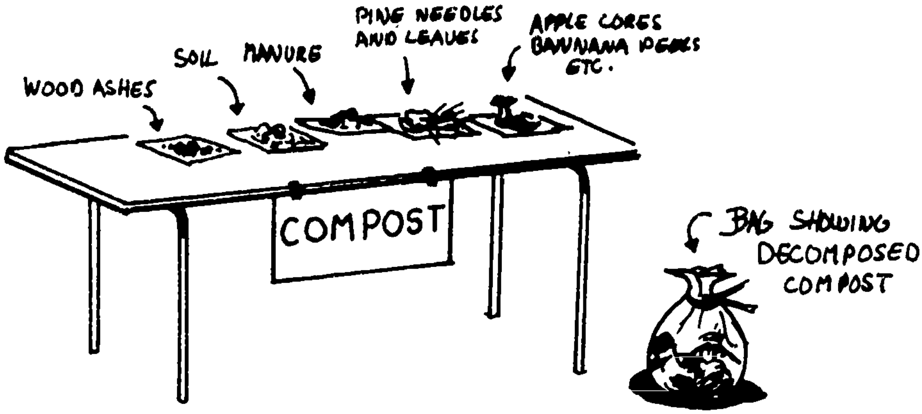


Figure C2-6

Macrame Group -	"We sat behind the desk and no one could see us do the different knots. They only saw the finished product." "Next time we'll demonstrate each knot for them."
Soil testing -	"We got tongue-tied. We didn't show them our cabbage experiment--the different sizes of red cabbage started April 3. We really goofed!"
Greenhouse - Demonstration	"We didn't know what was what and we didn't have enough information to keep them busy for 1/2 hour."
Transplanting -- and Seed-Starting Group	"Not enough posters advertising our show."

Two other groups came in, and after each had left we discussed how the session had gone. By now, the children were really learning how to run their demonstrations. They were much more sure of themselves. I was also impressed by the way they handled one group of younger children. They made a sign for a Mimosa plant which said "Touch it and see what happens." They showed the amazed young ones how to time the number of seconds it took for the leaves to close up after each touch.

The last group consisted of children from a junior high

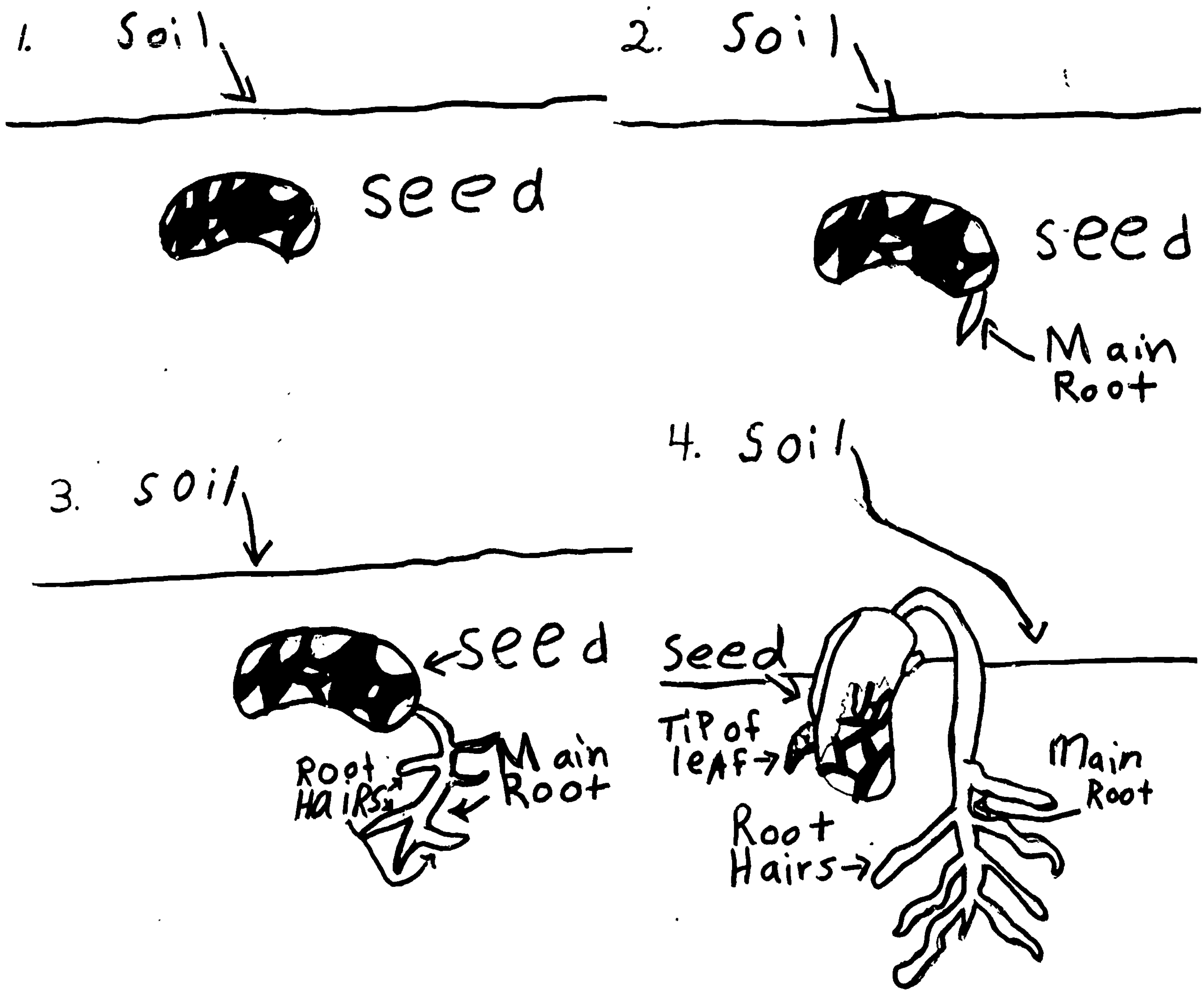

1. Soil
seed
2. Soil
seed
Main Root
3. soil
seed
Root Hairs
Main Root
4. Soil
Seed
Tip of leaf
Root Hairs
Main Root

Figure C2-7a

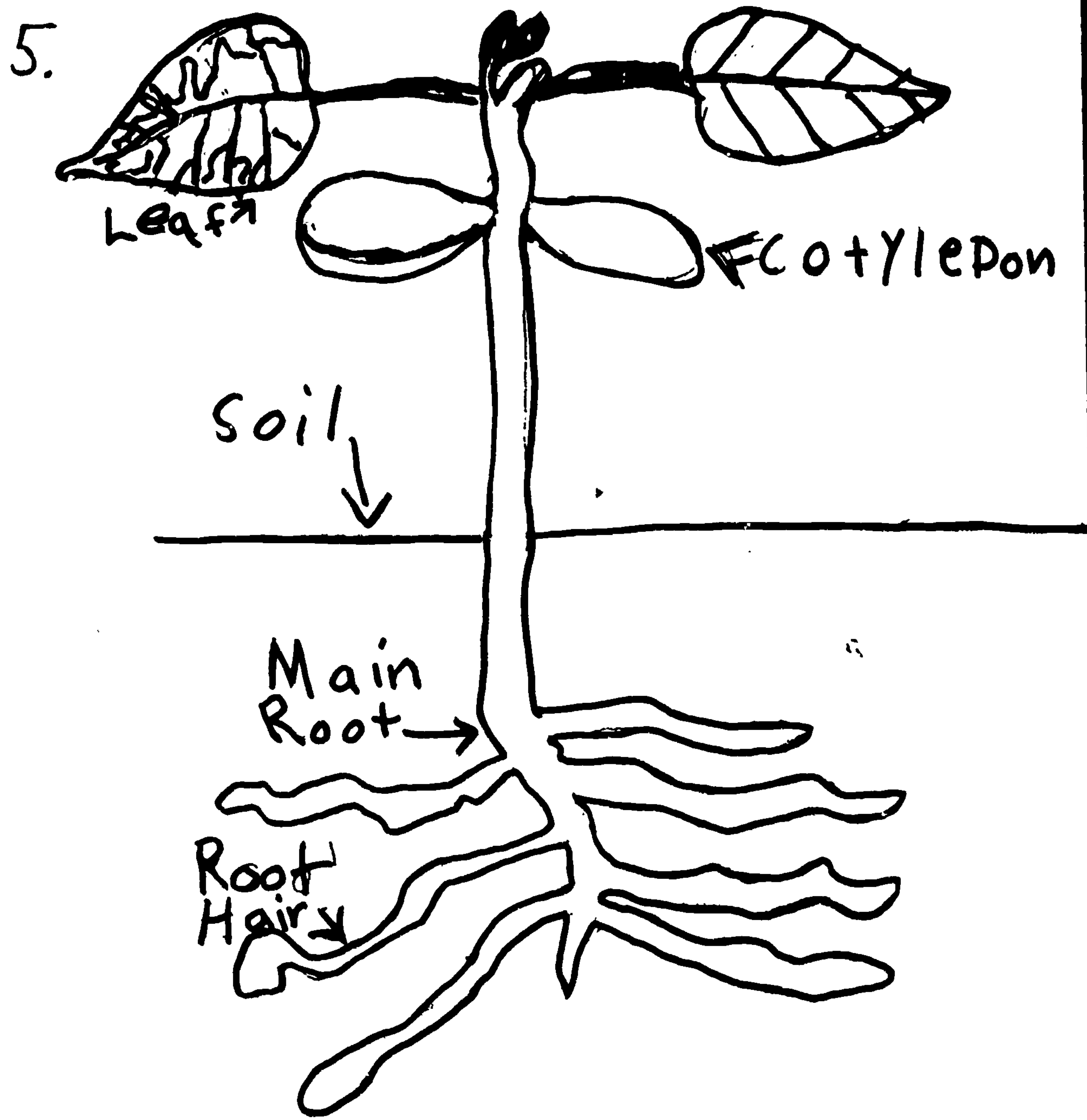


Figure C2-7b

school. The demonstrations for this group were polished. The soil-testing group had laid out soils of all kinds, and they asked the older children to test the various types. Those which were too alkaline were mixed with pine needles and retested; those which were acid were mixed with wood ashes and retested. The junior high kids asked if different kinds of wood created ashes with different pH values. The children in the group said that their ashes were hardwood (although they didn't know the kind); if anyone's parents burned soft wood, they would test the ashes for them.

During the first session, the transplanting and seed-starting group had been asked to sell some of the lettuce plants. They had made $2.64. The other children looked with envy on this money-making activity and began to sell their wares. When the junior high students requested free potting soil, the soil-making group told them that it "costs money." They didn't know how much to charge, and so they set a rate of 5¢ for a small pot of soil and 10¢ for a larger one. They also showed the other children how to make the soil by combining peat moss, soil, perlite, and sludge. The older children made each batch, tested it for pH, and then had it corrected by the soil test group.

The macrame group had made posters of their knots. They demonstrated how to make each knot, then cut it off, and taped it next to its picture on the poster. They set the price of macrame hangers at 65¢-85¢ each and nearly sold out their supply.

The only group which did not do too well was a group with an exhibit on the life of a seed. They had made drawings of each stage of growth as a seed germinates into a small plant (See Figure C2-7 a and b for an example of their diagrams.) They were to use examples to indicate the various stages of growth. They potted everything they had, moved their site, and began to sell their goods. One boy sold an 8" plastic pot with four blossoming bean plants of one-foot each for $1.50.

After the Open House, I asked the children what had happened to their original challenge of growing plants for poor people and old people.* They became very quiet as they realized that they had <u>sold</u> many of the plants which they had grown to give away. Silence prevailed for several minutes until one boy said "We could easily grow more."

Another added, "We have a lot of flowers that we could bring over to the home for the aged."

*The teacher might ask the children from time to time during the course of the unit how they plan to meet the challenge they have chosen.--ED.

Still another said, "Then we can still sell our vegetables." Everyone laughed, and I assured them that they had done a good job. A few days later, the children made plans to repot flowers and vegetables to take to the nursing home. before school ended for the year.

3. LOG ON GROWING PLANTS

by Steven Hanson*
Monte Vista School, Grade 6
Monterey, CA
(October 1974-May 1975)

ABSTRACT

This sixth-grade class at the Monte Vista School in Monterey, California, spent from four to eight hours per week on the challenge of growing houseplants for the school carnival in May. The students formed their own company to sell stock certificates within the class at 10¢ each, and they used the money raised to buy plant supplies such as soil, pots, fertilizer, macrame twine, and a few houseplants. Another group of children conducted a survey of other children in the school to find out which plants would be most popular for buyers. Other groups were formed to research information in library books on the needs of growing plants and to make a greenhouse from a large wooden box covered with plastic to retain moisture. Later in the year a fluorescent and incandescent light system was rigged over the greenhouse to give the plants additional hours of light. Children conducted several experiments with plant cuttings to see if they rooted better with or without Rootone, in the light or in the dark, in warm or cold temperatures. They also kept plant growth records in the form of charts, graphs, and daily logs. The students decided to sell the plants only within the class so that they would have a chance to buy them as Mother's Day gifts. After a long discussion, the class reached a compromise on whether the plants should be auctioned or sold at a fixed price. The hanging plants were auctioned and the rest were sold at prices set by the students. After totalling their return from the sale, they figured that each stock share was worth 25¢ and paid each child the increased value of his/her investment.

My class began by discussing the display of houseplants at Macy's downtown. The students remembered that large, healthy plants in the store cost $18 to $20, while small plants of the same variety cost 49¢ in the supermarket. The class discussed what could be done to make plants large and

*Edited by USMES staff

healthy. Since interest seemed to be high during the discussion, I asked the students if they thought it would be possible to set up a nursery in the classroom for raising large numbers of houseplants inexpensively. The class arrived at the idea of selling stock in class to raise money for supplies and then selling the plants for a profit at the school carnival. The enthusiasm was overwhelming.

The class listed things that needed to be done before they could begin growing the plants:

1. bring plants, soil, and fertilizer
2. identify types of plants and growing needs
3. find types of plants people like
4. sell stock to raise money
5. build greenhouse.

With these purposes in mind, the class divided into five committees with up to six people in each.

1. Survey group--determined buyer preferences--who likes what kinds of plants.
2. Reference group-- identified different kinds of houseplants with the help of reference books. Also found what they could about the conditions different plants like best.
3. Stock selling group--responsible for designing stock certificates and selling the shares to members of the class.
4. Project runners--bought supplies with money raised by stock sellers.
5. Greenhouse builders--converted large box used in class last year for studying stream life into greenhouses.

The "survey" group began by compiling a list of houseplants which the students had in their homes. They decided to limit the nursery to about ten types of plants. After asking around, the group discovered that not everyone knew what a coleus looked like or could tell the difference between a Boston and an asparagus fern. The children decided to bring examples from home to find out which plants were the most popular. They took a few of the plants to other classes to find out which plants they liked most. Then they made a display of different types of plants in front of the cafeteria for more children to see. They made a list of twenty plants and chose the ones that were voted most popu-

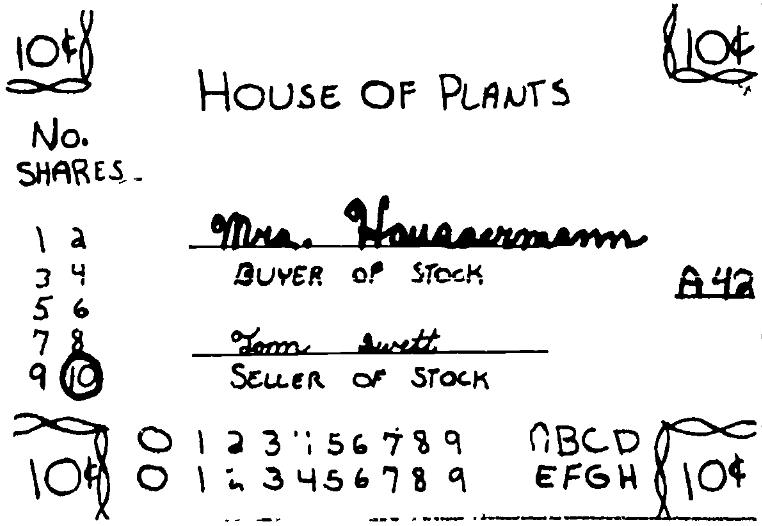


Figure C3-1

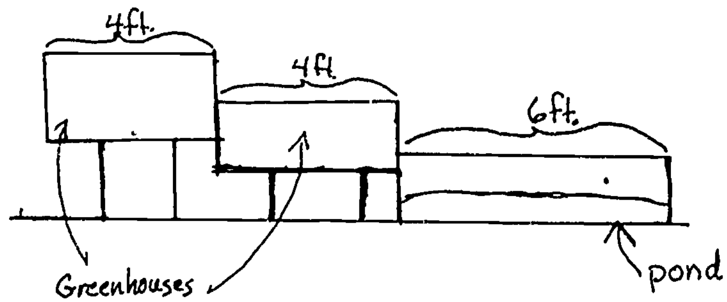
lar as plants to grow in our classroom, including coleus, wandering Jew, jade tree, and asparagus fern. As the year progressed, the children also began to grow other plants such as spider plants, blood leaf, and Swedish ivy in large numbers.

The "reference" group began looking for books to help them identify plants. Once the survey group had determined which types were the most popular, the students in the reference group began researching basic requirements for growing the various plants. They compiled a list of recommended light, fertilizer, and water conditions from information obtained from such books as Good Housekeeping Indoor Plant Book.

The "stock" committee decided that their company needed a name. After suggestions were listed on the board, students decided to call their operation the "House of Plants." The stock group also designed a stock certificate to be sold for 10¢ each. The certificate they made is shown in Figure C3-1. They started a stock file to keep records on buying and selling stock.

The company raised over $30.00 for buying plant supplies during the year. The class voted on the purchase of all supplies, which included a few plants such as wandering Jew and coleus, clay pots, soil, plant food, Rootone, and later in the year, macrame yarn for making plant hangers. The class spent a large portion of the money they had raised on material for macrame, which was quite expensive.

The group in charge of building a greenhouse decided to use the upper two containers of the stream box designed in a previous USMES class, keeping the lower box for raising pond animals. A diagram of the stream box is shown below.



The question arose as to whether the plants should be put directly in soil or kept in clay pots inside the greenhouse. The class decided to keep the plants in clay pots so that they would be easier to move. The "greenhouse" group stapled heavy plastic sheeting to the wooden frame lids to seal

Rooting Experiments

1. Warm vs. cold
(room temp. vs. refrigerated)
The warm temperature plants grew better.

2. Light vs. dark
(window sill vs. closet)
The plants grown in light grew better.

3 Love vs. no-love
(talking to vs. not talking to)
The plants with love were shorter but fuller. The plants with no-love were taller but not as full.

4 Music vs. no music
(radio vs. no radio)
There was no difference

5 Rootone vs no rootone
The plants with no rootone grew better.

6. Vermiculite vs. no vermiculite
The plants with vermiculite grew better.

Figure C3-2

the greenhouse and keep the potted plants inside moist. As soon as the plants were rooted, the students began putting them in the first of the two greenhouses.

The students decided to monitor different ways of rooting stem cuttings from the plants they'd brought in or purchased. I asked them what conditions they could vary to find the best environment for quick root growth. One student suggested that they find out whether plants root better in warm or cold conditions. Another wanted to test dark vs. light conditions. Other ideas included Rootone vs. no Rootone, music vs. no music, love (talking to plants) vs. no love. We listed possible experiments on the board. Volunteers chose the group with which they wished to be involved and met to plan the details of their experiments. I asked them to keep records to support any findings they made. The students kept track of root growth by counting the number of root shoots and measuring their lengths.

The group experimenting with Rootone used a medium of sand and vermiculite. They found that wandering jew cuttings that were not dipped in Rootone seemed to grow better than those with Rootone. Two girls were successful in getting coleus to root in a bottle of plain water on the window sill, while the control plant in the dark did not root at all. One child's summary of the results of these rooting experiments is shown in Figure C3-2. The students seemed to feel that experimenting with one set of plants was adequate. I suggested that the children substantiate their results by growing more than one plant under each condition, but the children were slow to respond to this idea. Several groups made bar graphs or line graphs of the results of their experiments. An example of a bar graph made by the children is shown in Figure C3-3. A line graph is shown in Figure C3-4.

The stock committee discussed the possibility of varying the value of the stock according to the market. The students realized that as the worth of the company rose, 10¢ might be too low a price for each share. Some group members felt that a system that would cause the price of stock to fluctuate as demand increased or decreased was needed. A majority of the group, however, decided that they were content with things as they were. The group kept records of stock sales and made a bar graph to show how the buying varied over a period of several weeks. (See Figure C3-5.)

The children decided that the plants in the greenhouse were not receiving enough light because the classroom window faced north. They wanted to install Grow-lites. Since I knew how expensive these were, I suggested instead that

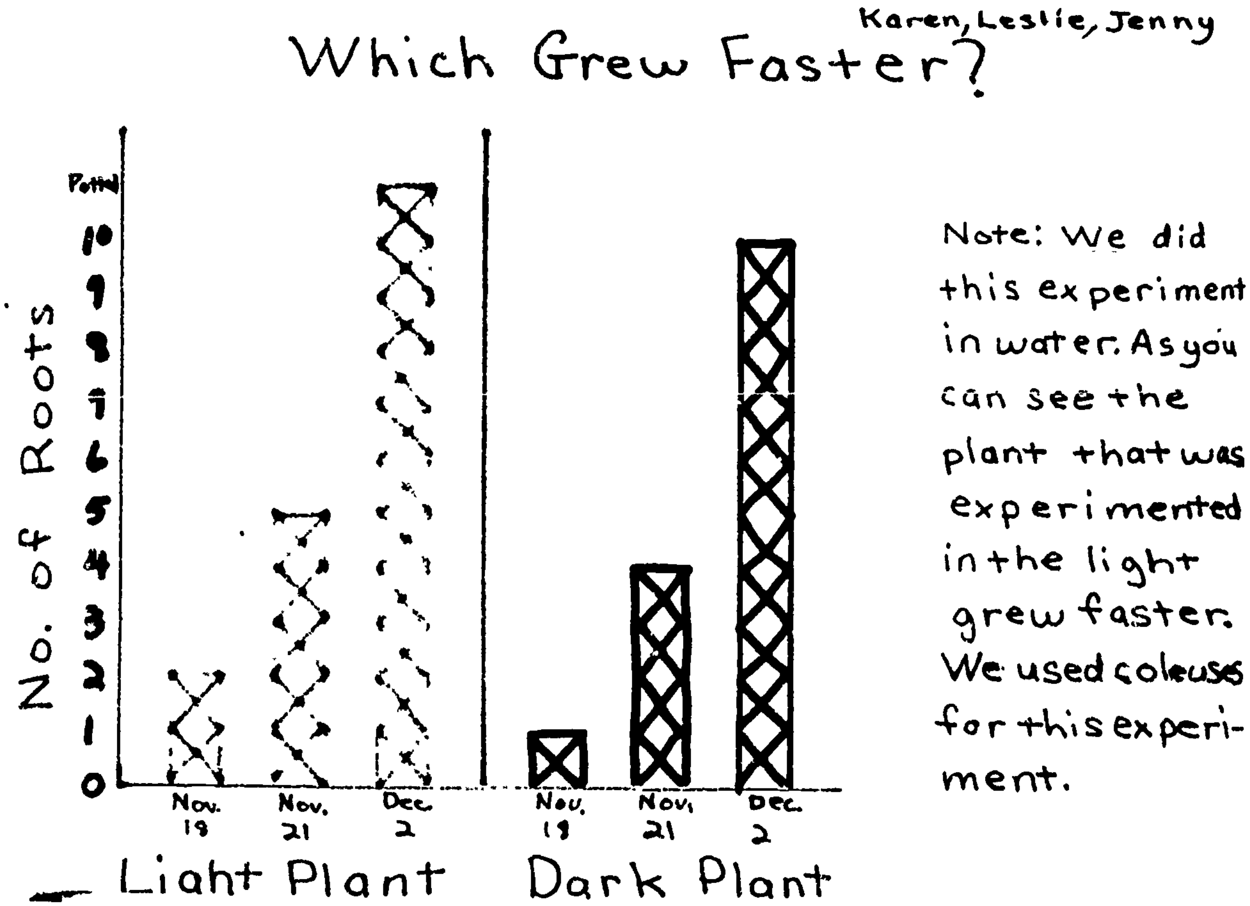


Figure C3-3

they try a fluorescent fixture with a tungsten bulb which would provide an even greater light intensity. The students installed a thirteen-inch fluorescent tube and a 40-watt bulb for the four-foot-square plant box. We attached the light to a timer set to expose the plants to an extra eight hours of light. The additional light seemed to keep the plants healthier than before.

When the first greenhouse was filled with plants, the students wanted to expand into the second and rig a similar light system. The cost of the fluorescent fixture was too high for the class, however. The students also felt that simply keeping plants of the types they were growing in a covered, humid container seemed to be enough to make them do well. They moved many of the larger plants out of the

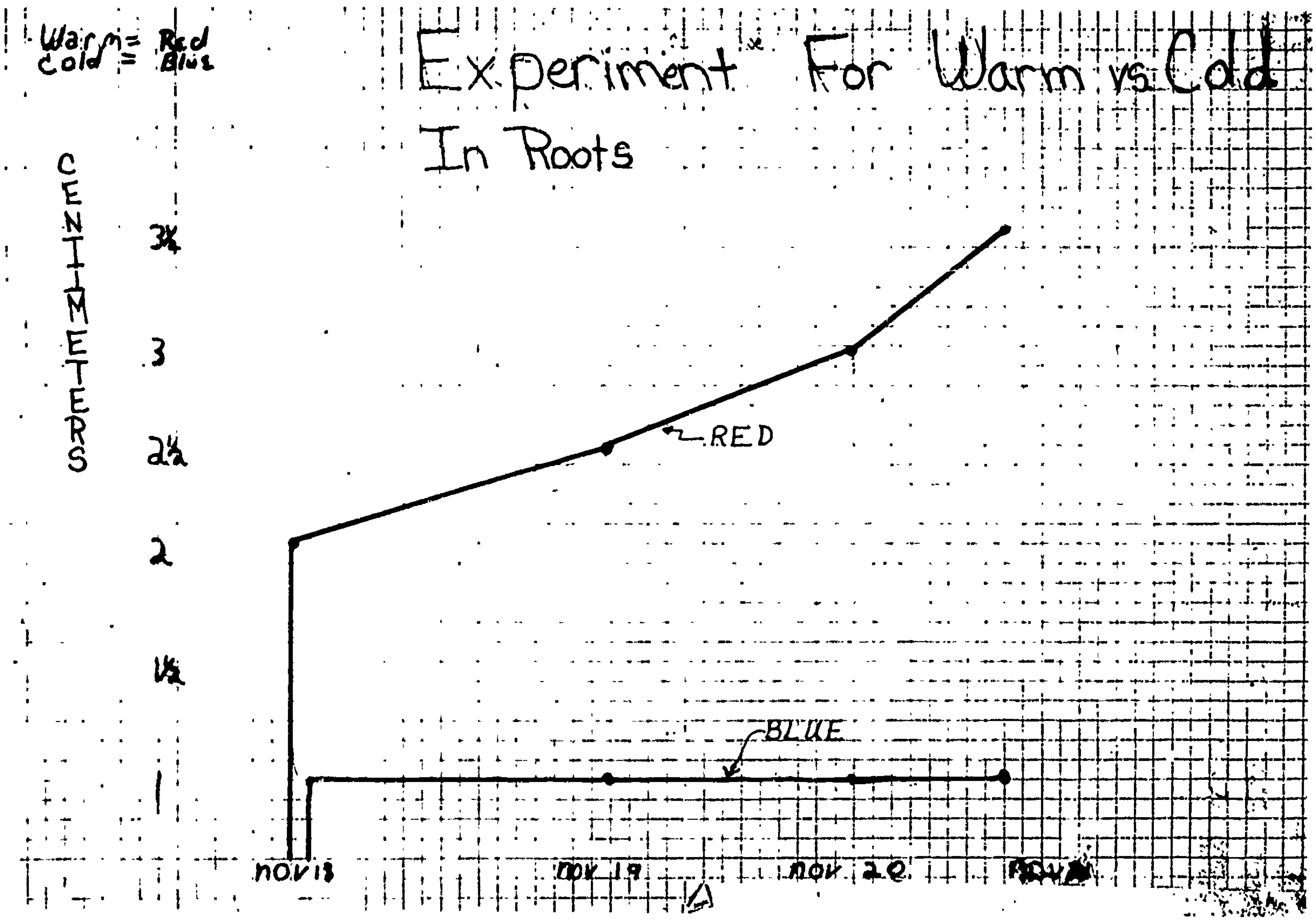

Warm = Red
Cold = Blue
Experiment For Warm vs Cold In Roots
CENTIMETERS
3¼
3
2½
2
1½
1
RED
BLUE
NOV 18
NOV 19
NOV 20

Figure C3-4

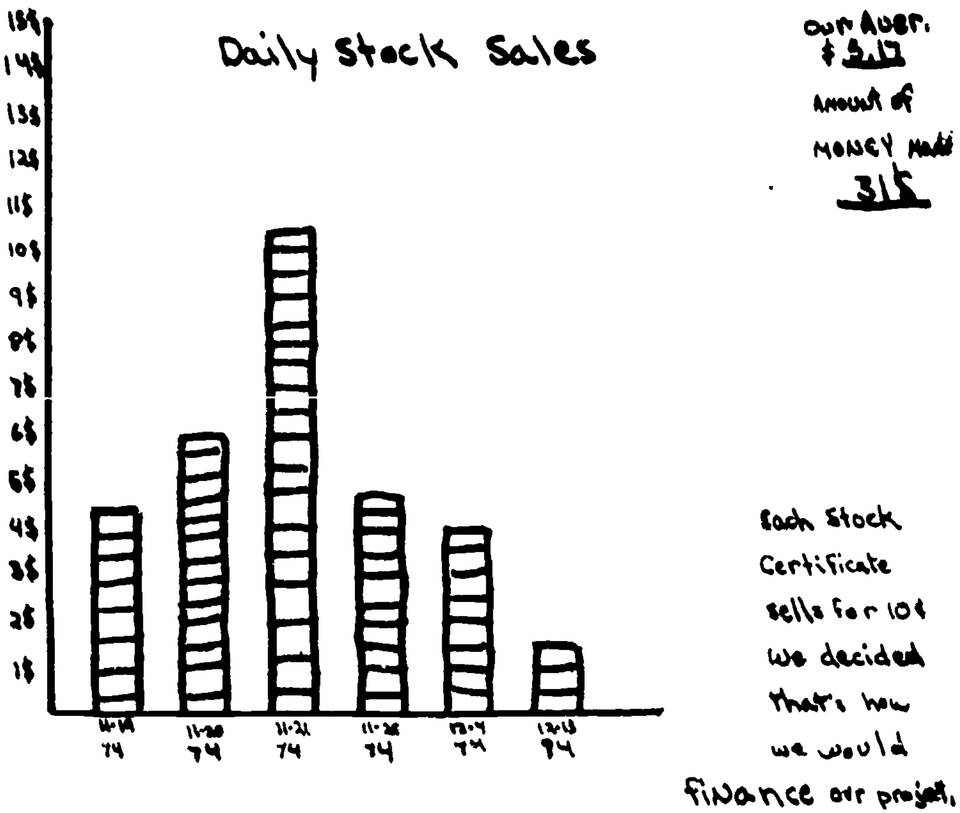
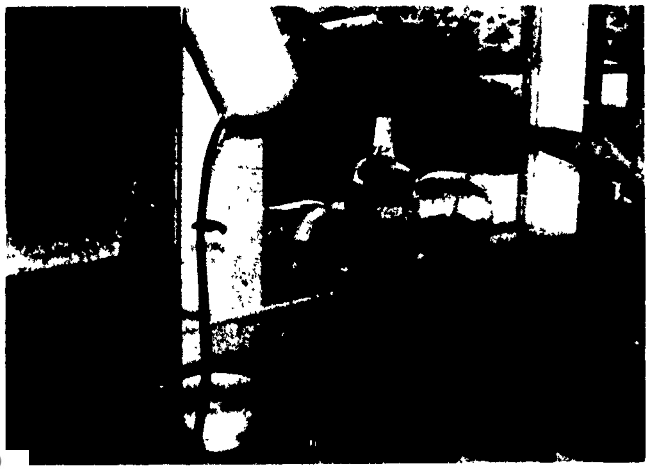


Figure C3-5

lighted greenhouse and hung them around the room.

Since our first set of groups formed, we had been reorganizing them according to our needs. The stock/finance committee remained throughout the unit, but we dissolved the other old committees and formed new ones as the need arose: for experimenting with plants to gather information on their needs; for starting plants by rooting slips; for making clay pots and macrame plant hangers. A terrarium committee was also formed which researched several books to find out what plants grow best in terrariums and made three from containers which they scrounged.

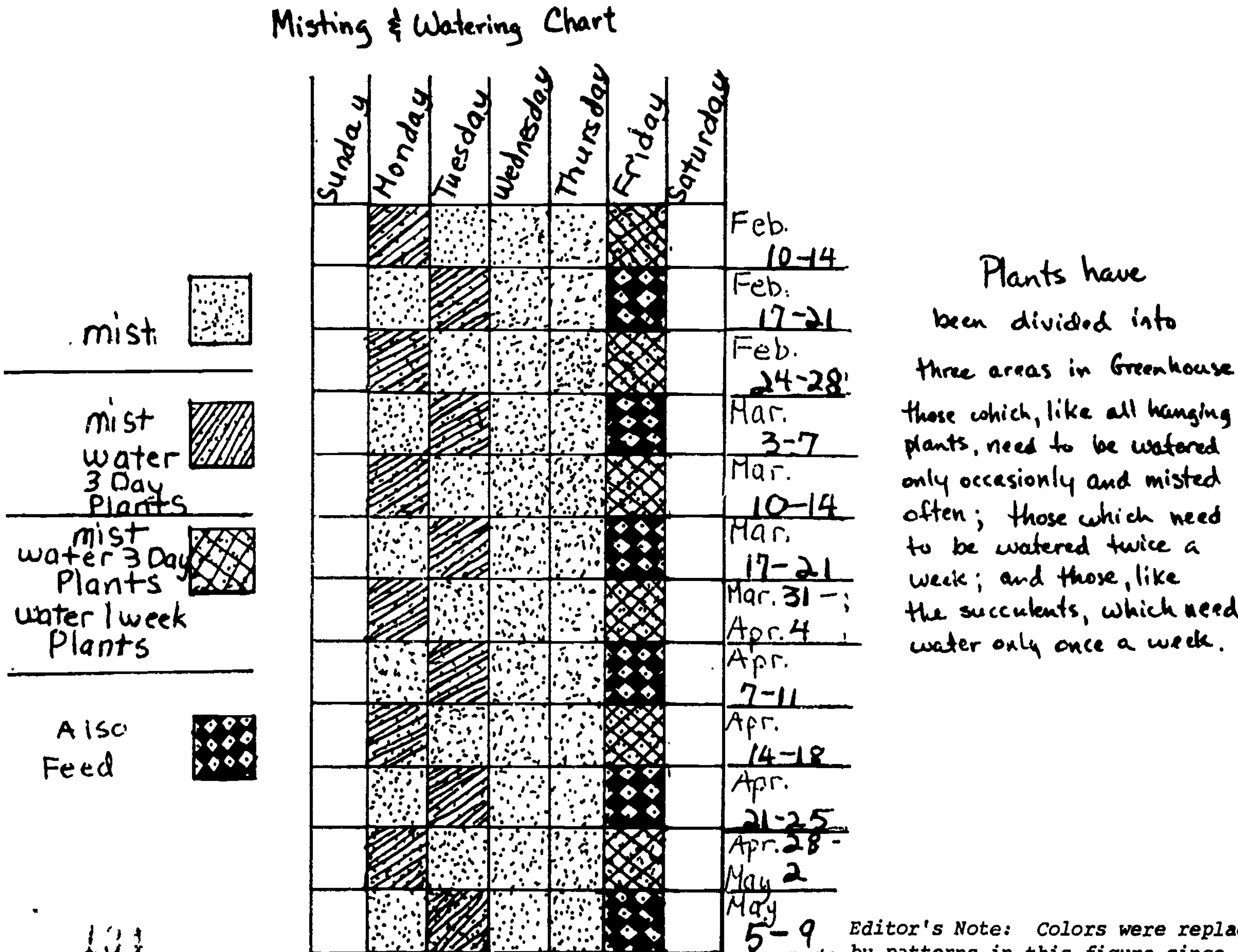
One of the students made a color-coded chart to serve as a guide for taking care of the plants. The chart explained when different plants should be watered and misted. Twelve students volunteered to rotate the duties so that two different people cared for the plants each week. The students also made scale drawings showing where the different kinds of plants were located in the greenhouse and posted the drawings and chart next to the plant boxes.



Later, the children decided to revise their feeding and

watering schedule because some of the plants were receiving too much moisture. They discovered that the coleus plants were discoloring because they were being misted every day. The box was then divided into three specific areas; plants to be misted daily, plants to be watered every three days, and plants to be watered weekly. Only asparagus ferns, spider plants, and wandering Jews were misted regularly. All plants were given a dose of plant food every two weeks. (See Figure C3-6 for the schedule.)

Figure C3-6



Editor's Note: Colors were replaced by patterns in this figure since color could not be reproduced in this book.

The children stuck popsicle sticks with numbers on them in the soil of each pot; a chart on the wall identified the numbers with the name of the plant. Another chart was made showing which students were responsible each week for plant care. Organizing a maintenance schedule for the plants decreased the amount of time involved in care and eliminated the duplication of effort that had previously been a problem.

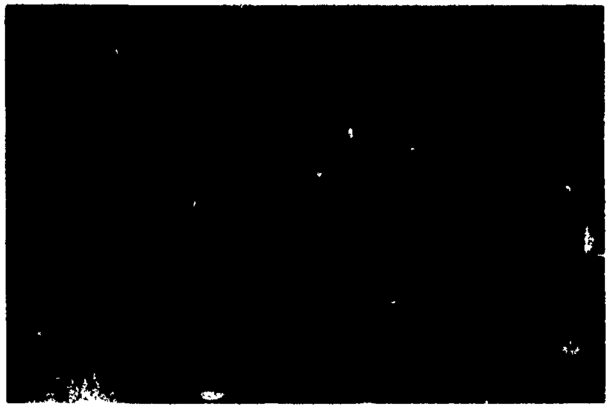
Toward the end of January, the students evaluated their plants and decided to have a preliminary sale to obtain working capital to reinvest. They also felt that this initial sale would bring some publicity to the high quality product that "House of Plants" had to offer and would help them to determine how well their plants would sell. They decided not to sell all of one kind of plant so that they could continue to propagate new plants from slips.

The sale generated considerable class discussion on why the plants should or should not be sold and who should buy them. Some children felt that the class should keep the plants until the end of the year when they would be even larger and would bring in more money. But others felt that some catastrophe could wipe out all the money that they had invested in the plants, and it would be better to try to get some return while we still had healthy plants. Also, some people felt that people would not want to spend too much money on the plants and would prefer to buy them while the price was reasonable.

The sale was set for Valentine's Day, and a committee was formed to determine prices for the plants to be sold. After evaluating our supply, they decided that only five plants were mature enough to be sold and that only about $10.00 could be raised from this small number. This discovery led to another class discussion. One student suggested that we auction the five plants within the room to raise more money, and the class enthusiastically accepted this solution.

We held an auction on Valentine's Day of two asparagus ferns (standing type), a spider plant, a geranium, and a blood leaf. The class made the rule that any one student could buy only one plant. The bidding for each plant was higher than had been expected; the company made $14.30 on the plants.

Following the sale, two girls took an opinion poll to see how the class would like to invest the money they had made. The class voted to buy more asparagus ferns, wandering jews, and spider plants, and a committee was formed to purchase these plants. A wandering Jew, a spider plant, and a small



asparagus fern were hung in macrame holders in the room for "advertising" purposes. Several children offered to purchase these plants, but the class decided not to sell any more plants at this point. During Easter vacation the children took the plants down and put them in the greenhouse so that they would receive more moisture.

In addition to buying more plants, the students invested money from the plant sale in buying enough macrame jute to make about ten more hangers. Two boys investigated prices of clay pots and tried to find the best deal on 4" and 5" pots.

The students began making a bulletin board display of various plant-raising techniques for advertising their project and teaching others how to care for plants. They included information they had researched from books or discovered from experimenting with plants, such as the "dos and don'ts" of rooting techniques. The children included many of the graphs they had made on rooting experiments in the display.

Students started new slips in an attempt to increase the number of plants in the greenhouse. Using the rooting conditions that they had previously determined to be advantageous--coke bottles filled with water in lighted portions of the room--the students started nine slips. The cuttings were taken from plants in the class or brought from plants at home. The children kept logs on the progress of their plants. While the plants were rooting in water, we recorded length and number of root shoots at regular intervals. Again, children made graphs of their data, such as the one shown in Figure C3-7. We planted the cutting after the roots had begun to grow and kept records of stem and leaf growth. The students noted in a log how plants would grow faster at first, sprouting leaves every few days, then slow down and put out a leaf perhaps once a week. (See Figure C3-8.) Our blood-leaf plants were especially prolific; we were able to propagate several plants by picking off the tops of mature plants and putting the cuttings in soil with Rootone. Other plants the children rooted at this time were coleus, wandering Jew, and Swedish ivy.

At the end of April, the students began discussing how they were going to sell their plants for the school carnival. This discussion led to a debate in which half the class favored an auction and half favored fixed prices. Those in favor of holding an auction felt that plants should go to the highest bidder. These students argued that the investors took the financial risk and should therefore be allowed to reap as much profit as possible. The group favoring

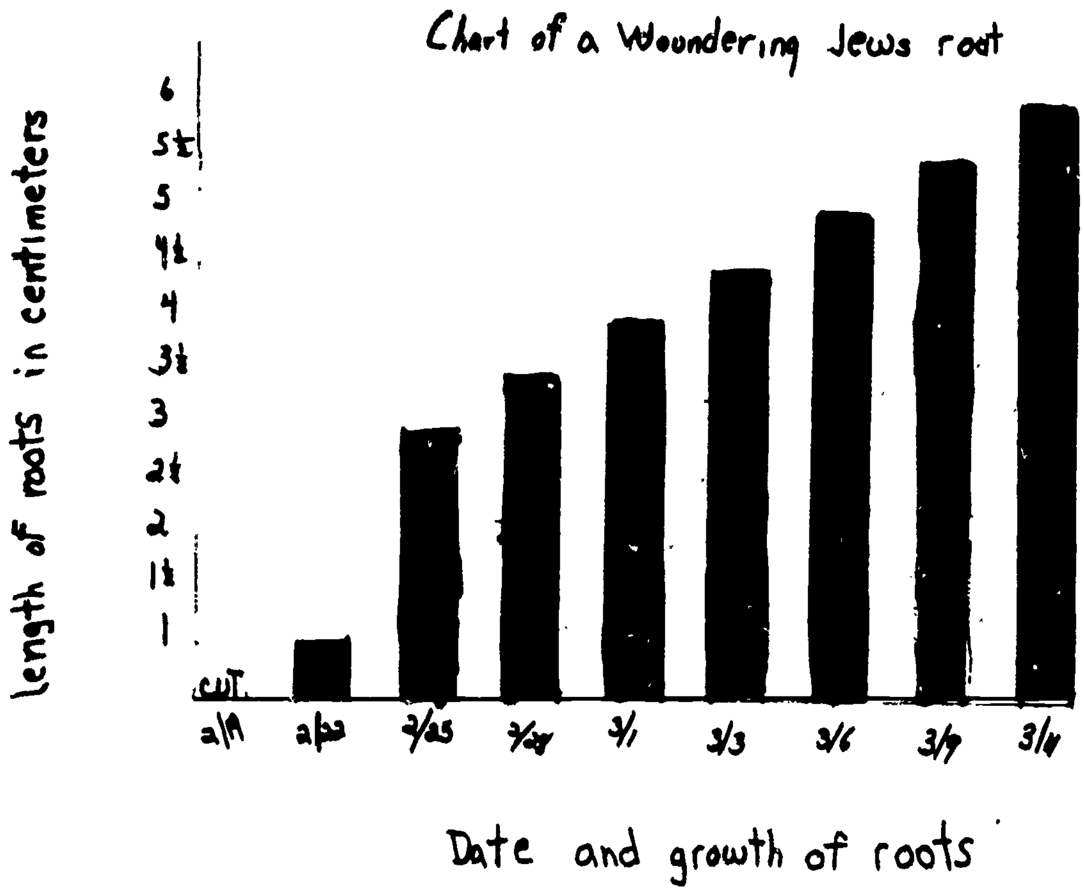


Figure C3-7

fixed prices felt that prices should be kept down so that students in the class could afford to buy the plants they had helped to grow. They argued that auctions exaggerated prices and that the whole idea of forming the "House of Plants" was to grow plants economically so that they could then be sold more cheaply than plants in the store. The "auction" group countered that if only seven plants were hanging in macrame holders and that if each were priced at $5.00, there would be a stampede to grab the plants and not everyone would be able to have one anyway.

As the class was becoming more and more divided on the issue, I told the class that they would have to work out an arrangement in which two-thirds of the class agreed.*

*Another way of solving the disagreement might have been to ask students if there were ways the plants could be distributed fairly so anyone who wanted them would have a chance, such as by having draws. --ED.

Woundering Jew

Date	Height	Leaves
2/26/75	8 center meters	6
2/27/75	8½ centermeters	6
3/3/75	9 centermeters	6
3/5/75	9½ centermeters.	6
3/7/75	10 centermeters	6
3/11/75	11 centermeters	7
3/13/75	" "	7
3/18/75	12½ centermeters	8

Diary Feb 25-

We have a plant called Woundering Jew. We brougth it to school on Feb 25, 1975. We watered it once a 11:50 in the morning.

We have had the plant for two days now and its grow a hafe an inch I watered it at 1:45 in the afternoon. The date is Feb 27, 1975 Thursday.

This plant of ours has only had 6 leaves for the last seven days. We watered it at 1.45 in the after-noon. The date March 3, 1976 mon-day.

Figure C3-8

Who bought shares Person	No. of shares bought from company at 10¢ a Share	dollars invested in Co. $	total amount paid by company at 25¢ a share. total
Susan Ball	70	7.00	17.50 $
Larry Bohn	55	5.50	13.75 $
Luke Curtice	9	.90	2.25 $
Greg Finch	48	4.80	12.00 $
John Guaracio	7	.70	1.75 $
John Hudson	10	1.00	2.50 $
Ann Hilleary	1	.10	.25 $
Jenny Jhonson	1	.10	.25 $
Jon Law	7	.70	1.75 $
Todd Meyer	1	.10	.25 $
Sandra Millon	10	1.00	2.50 $
Phyllis Mines	2	.20	.50 $
Cathy Murnighan	10	1.00	2.50 $
John Pama	11	1.10	2.75 $
Paul Riso	5	.50	1.25 $
Barney Russ	45	4.50	11.25 $
Tom Swett	4	.40	1.00 $
Luana Wythe	7	.70	1.75 $
total	303 Shares	$30.30 dollars	75.75 $ was paid by the company at .25¢ a share

Figure C3-9

Realizing that they would have to compromise, the children began to make new suggestions. One of the girls who had favored not auctioning suggested that we auction the seven hanging plants and sell the others at a fixed price. This idea received a great deal of support from the rest of the class. The students also discussed whether we should sell plants separately from hangers since some of the hangers looked rather shabby. The class was overwhelmingly in favor of selling all plants as they were with no changes.

Since the plants were so popular, the children decided to sell them only within the class, not at the school carnival as planned.* The sale/auction was voted for May 8 so that the children would be able to purchase the plants as gifts for Mother's Day. Each student was allowed to buy only one plant until everyone had been given a chance to pick. Even the auctioned plants sold at lower prices than can be found at most stores. The "House of Plants" made approximately $76.00 from the approximately forty plants, two terrariums, and containers sold during the in-house sale. The children computed that the stock which had sold for 10¢ a share was now worth 25¢ per share by dividing the total money spent into the money received at the sale and multiplying the figure (2.5) by 10¢. They calculated each person's share and distributed the money to the investors. A chart showing each student's investment is displayed in Figure C3-9. The overall feeling in the class was that the sale and the work on the challenge were a great success.

*The children might have considered whether or not it would have been feasible to grow enough plants to sell at the carnival as well as within the class, taking into consideration spatial limitations of the classroom.--ED.

D. References

1. LISTS OF "HOW TO" SERIES

The *USMES "How To" Series* are written resources that help children learn skills they need to solve real problems (e.g., designing an opinion survey, drawing various types of graph).

"HOW TO" CARDS

Below are listed the current "How To" Card titles that students working on the Growing Plants challenge may find useful. A complete listing of both the "How To" Cards and the Design Lab "How To" Cards is contained in the USMES Guide. In addition, the Design Lab Manual contains the list of Design Lab "How To" Cards.

GRAPHING

GR 1 How to Make a Bar Graph Picture of Your Data
GR 2 How to Show the Differences in Many Measurements or Counts of the Same Thing by Making a Histogram
GR 3 How to Make a Line Graph Picture of Your Data
GR 4 How to Decide Whether to Make a Bar Graph Picture or a Line Graph Picture of Your Data
GR 5 How to Find Out If There Is Any Relationship Between Two Things by Making a Scatter Graph
GR 7 How to Show Several Sets of Data on One Graph

MEASUREMENT

M 2 How to Measure Distances
M 9 How to Make a Conversion Graph to Use in Changing Measurements from One Unit to Another Unit
M 10 How to Use a Conversion Graph to Change *Any* Measurement in One Unit to Another Unit

PROBABILITY AND STATISTICS

PS 2 How to Record Data by Tallying
PS 3 How to Describe Your Set of Data by Finding the Average
PS 4 How to Descirbe Your Set of Data by Using the Middle Piece (the Median)
PS 5 How to Find the Median of a Set of Data from a Histogram

RATIOS, PROPORTIONS, AND SCALING

R 1 How to Compare Fractions or Ratios by Making a Triangle Diagram*

*Now called slope diagram

BEGINNING "HOW TO" SERIES

The cartoon-style format of this series helps younger children and those with reading difficulties acquire the skills and knowledge they may need during work on Growing Plants.

COLLECTING DATA

"How To" Record Data
"How To" Do an Experiment
"How To" Make an Opinion Survey
"How To" Choose a Sample

GRAPHING

"How To" Choose Which Graph To Make
"How To" Make a Bar Graph
"How To" Make a Bar Graph Histogram
"How To" Make a Conversion Graph
"How To" Make a Line Chart
"How To" Make a Line Graph
"How To" Make a Scatter Graph
"How To" Make a Slope Diagram

MEASURING

"How To" Choose the Right Tool to Measure Distance

SIMPLIFYING DATA

"How To" Round Off Data
"How To" Find the Median
"How To" Find the Average

INTERMEDIATE "HOW TO" SERIES

This booklet-style series covers in more detail essentially the same information as the *Beginning "How To" Series* with a few booklets on additional skills. This series requires a greater reading skill and gives students a chance to read something they have a need to read. Those pertinent to Growing Plants are listed below.

COLLECTING DATA

"How To" Collect Good Data
"How To" Round Off Data
"How To" Record Data
"How To" Do an Experiment
"How To" Make an Opinion Survey
"How To" Choose a Sample

GRAPHING

"How To" Choose Which Graph to Make
"How To" Make a Bar Graph
"How To" Make a Histogram
"How To" Make a Line Graph
"How To" Make a Conversion Graph
"How To" Use Graphs to Compare Two Sets of Data

MEASURING

"How To" Choose the Right Tool to Measure Distance

SIMPLIFYING DATA

"How To" Tell What Your Data Show
"How To" Find the Median
"How To" Find the Mean
"How To" Find the Mode
"How To" Find Different Kinds of Ranges
"How To" Use Key Numbers to Compare Two Sets of Data

2. LIST OF BACKGROUND PAPERS

As students work on Growing Plants, teachers may need background information that is not readily accessible elsewhere. The Background Papers fulfill this need and often include descriptions of activities and investigations that students might carry out. Listed below are those Background Papers that teachers may find pertinent during work on Growing Plants.

A Voting Procedure Comparison That May Arise in USMES Activities
A Strategy for Collecting Data/Measuring
A Strategy for Examining and Analyzing Data
Comparing Two Sets of Data: A Graphical Method
Comparing Two Sets of Data: A Mathematical Analysis
Hints for Growing Plants
How to Avoid Crop Failure and Disaster: Redundancy
How to Keep from Also Raising Aphids, Red Spider Mites, White Flies, etc., When Growing Plants

3. BIBLIOGRAPHY OF NON-USMES MATERIALS

The following are references that may be of use in teaching Growing Plants. A list of references on general mathematics and science topics can be found in the USMES Guide. (Publisher's prices, where listed, may have changed.)

Resource Books for Teachers

Chevron Chemical Company. *A Child's Garden.*
Single copies free to teachers, quantity prices available on request from Chevron Chemical Company, 200 Bush Street, San Francisco, CA 94104.

A gardening guide for parents or teachers that can be used with or without the film "Growing Growing." It has experiments that younger children can do with many drawings, diagrams, and sources of additional help.

Elementary Science Study (ESS), Teacher's Guides.
McGraw-Hill Book Co., Webster Division, Princeton Road, Hightstown, NJ

________. *Growing Seeds.*
Describes seed planting procedures and materials, and easy ways to keep records of plant growth.

________. *The Life of Beans and Peas.* Concentrating on two types of plants, the booklet describes plant needs and problems that could arise when children grow plants.

________. *Microgardening.* Molds are a common problem in growing plants. This booklet describes how to grow mold and may be useful if children want to experiment with their effects on plant growth.

________. *Starting from Seeds.* Describes experiments childrne can try with plants by altering factors such as light, temperature, or motion.

Foundational Approaches in Science Teaching (FAST). These experimental materials are not presently for distribution or sale. Write to University Laboratory School, University of Hawaii, Honolulu, Hawaii for information.

________. *Organism Maintenance - Reference Booklet.* Useful for teachers. Describes how to grow plants in different "microenvironments," in which water, light, and soil type may be varied.

________. *Plant Propagation - Reference Booklet.* Useful for teachers and older children. Describes how to grow plants from bulbs, cuttings, and seeds or under hydroponic conditions.

MINNEMAST Series. Available from Minnesota Mathematics and Science Teaching Project, Unifersity of Minnesota, 720 Washington Ave., S.E., Minneapolis, Minnesota 55455.

________. *Unit 23, Conditions Affecting Life.* Describes simple experiments to determine plant preferences for humidity and light.

National Wildlife Federation - Environmental Investigations. (Teacher Guides). Written by Minnesota Environmental Sciences Foundation, Inc. Available from NWF, 1412 Sixteenth St., N.W., Washington, DC 20036

________. *Differences in Living Things.*
Describes how to compare plants graphically by leaf area, length and number. Useful for children experimenting with growth conditions in plants.

________. *Plants in the Classroom.*
Describes how to grow different types of plants and keep records on them.

________. *Soil.*
Describes how to test soil for acidity, mineral, and microorganism content, and water-holding capacity. Useful for children experimenting with soil conditions for plants.

Rodale Press Educational Services Division, 33 E. Minor Street, Emmaus, PA 18049.

________. *The Organic Classroom.*
If students want to grow plants using natural fertilizers and pest controls, this booklet gives some useful ideas.

________. *Teaching Science with Soil* by Albert Schatz.
Useful for teachers. Gives basics of soil chemistry and plant nutrition.

Science Curriculum Improvement Study (SCIS). Available from Rand McNally & Company, Chicago, Illinois.
The books are teacher's guides useful for classes growing plants. They describe plant growth and interaction with environment.

Organisms
Life Cycles
Populations
Environments
Communities
Ecosystems

Resource Books for Students

Budlong, Ware and Fleitzer, Mark H., *Experimenting with Seeds and Plants.* New York: G.P. Putnam's Sons, 1970.
Useful for older children. Lists several experiments and activities for growing plants in the classroom.

Gambino, Robert. *Easy to Grow Vegetables*. New York: Harvey House Publishers (20 Waterside Plaza, NY 10010). 1975. ($4.29)
A book for the beginning child gardener with clear and complete instructions and realistic illustrations. It details the preparation, planting, care, and harvesting of nine vegetables.

Kramer, Jack. *Plants Under Light*. New York: Simon and Schuster, 1974.
Explains how to set up an artificial lighting system using incandescent and fluorescent lights. Useful for older children.

Paul, Aileen. *Kids Gardening*. Garden City, New York: Doubleday & Company, Inc. 1972.
Tells basics of planting and care in easy steps.

Russell, Solveig Paulson. *Like and Unlike: A First Look at Classification*. New York: Henry Z. Walck, Inc., 1973.
Basics of classifying things. Good for children learning to tell plants apart.

4. GLOSSARY

The following definitions may be helpful to a teacher whose class is investigating a Growing Plants challenge. Some of the words are included to give the teacher an understanding of technical terms; others are included because they are commonly used throughout the resource book.

These terms may be used when they are appropriate for the children's work. For example, a teacher may tell the children that when they conduct surveys, they are collecting *data*. It is not necessary for the teacher or students to learn the definitions nor to use all the terms while working on their challenge. Rather, the children will begin to use the words and understand the meanings as they become involved in their investigations.

Average — See *Mean*.

Bulb — A roundish mass of fleshy leaves formed by some kinds of plants which allows the plant to rest underground during the winter, e.g., onion, tulip.

Chlorophyll — A green substance in plants which helps them synthesize food.

Conversion — A change from one form to another. Generally associated in mathematics and science with the change from one unit of measure to another or the change from one form of energy to another.

Correlation — A direct or inverse relationship between two sets of data, pieces of data, etc.

Cotyledon — The first leaf developed by the embryo of a seed plant.

Cultivation — The process of taking care of plants and helping them grow.

Data — Any facts, quantitative information or statistics.

Dicot (Dicotylegon) — A plant which belongs to a large group of flowering plants putting out two cotyledons, or seed leaves, when it first sprouts, e.g., marigold.

Distribution — The position or arrangement of data over a certain area or space.

Embryo — The young plant formed inside a seed before it sprouts.

Environment — The conditions in which an organism lives, including temperature, light, water, and other organisms.

Fern — One of a group of plants which have stems, roots, and leaves but which reproduce by spores instead of seeds.

Frequency — The total number of times a certain event has occurred.

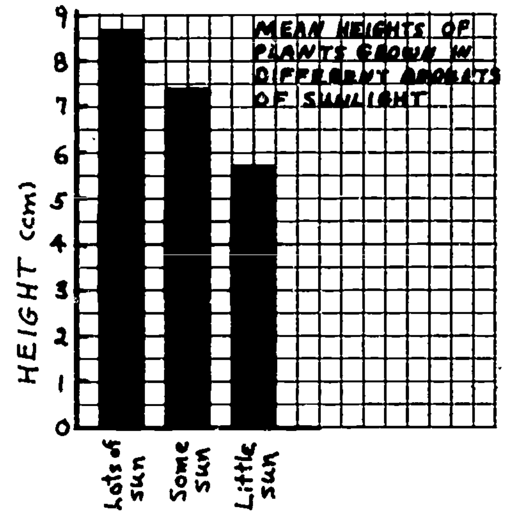
Frequency Distribution Curve — See *Histogram*.

Germination — The process a seed undergoes when it sprouts into a young plant.

Graph — A drawing or picture of one or several sets of data.

Bar Graph — A graph of a set of measures or counts whose sizes are represented by the vertical (or horizontal) lengths of bars of equal widths. For example, the mean heights of several groups of plants.

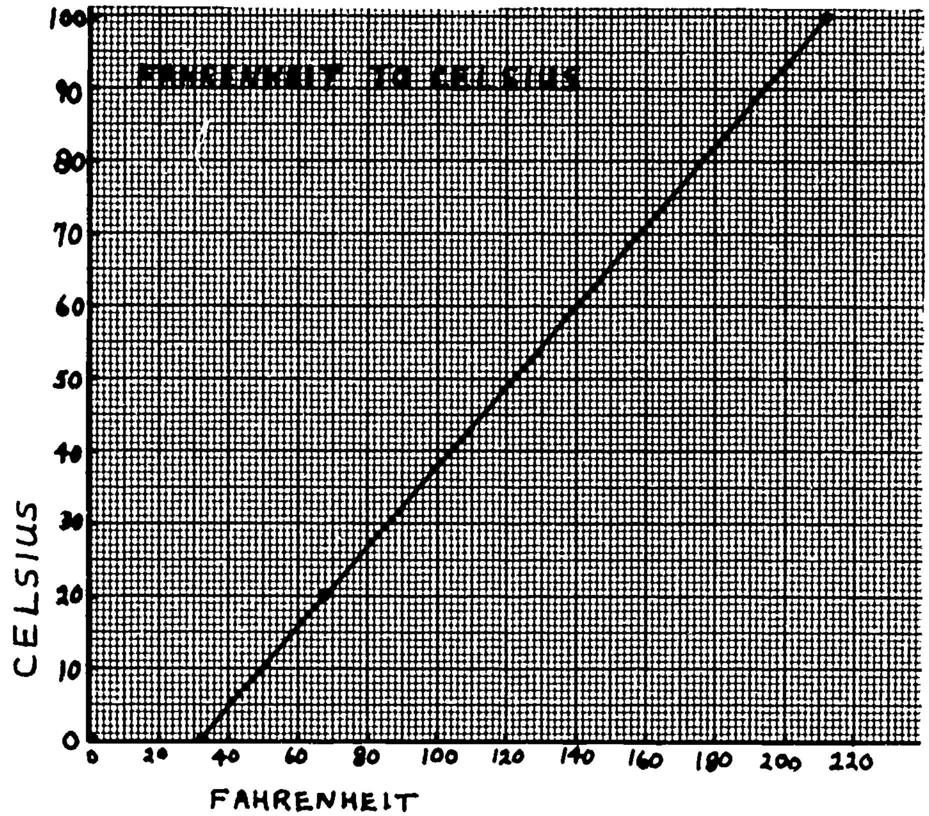
PLANT GROUP	MEAN HEIGHT (cm)
Lots of sun	8.7
Some sun	7.4
Little sun	5.7



Conversion Graph — A line graph that is used to change one unit of measurement to another. For example, changing degrees Fahrenheit to degrees Celsius and vice versa.

Conversion Graph (cont.)

FAHRENHEIT	CELSIUS
0°	0°
68°	20°
212°	100°

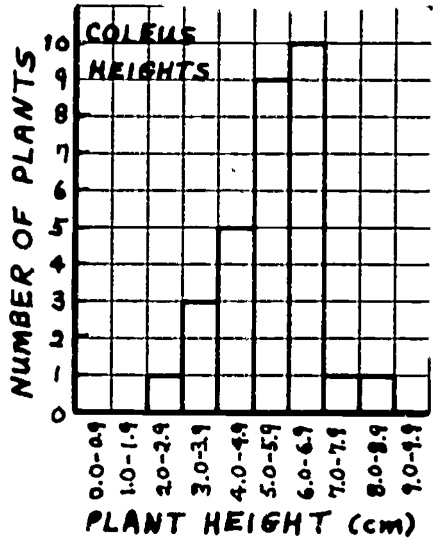


Histogram

A type of bar graph that shows the distribution of the number of times that different measures or counts of the same event have occurred. A histogram always shows ordered numerical data on the horizontal axis. For example, the number of plants of given heights in a group of like plants.

Histogram (cont.)

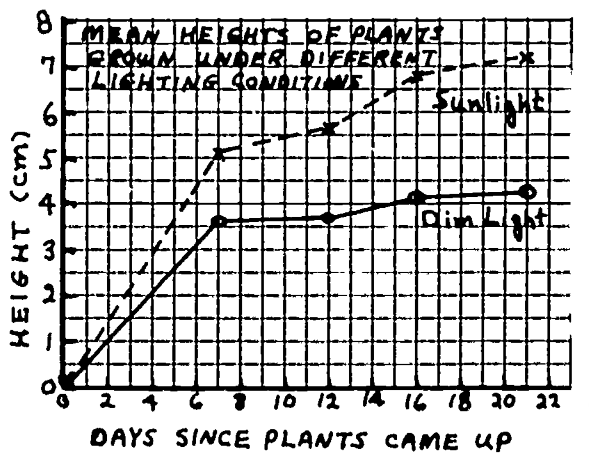
HEIGHT (cm)	NUMBER OF PLANTS
0.0-0.9	0
1.0-1.9	0
2.0-2.9	1
3.0-3.9	3
4.0-4.9	5
5.0-5.9	9
6.0-6.9	10
7.0-7.9	1
8.0-8.9	1



Line Chart

A bar graph that is represented by circles, crosses, or triangles with lines connecting them so that it has the appearance of a line graph (see *Line Graph*). This is a useful representation when two or more sets of data are shown on the same graph. For example, mean heights of different plants grown under different lighting conditions.

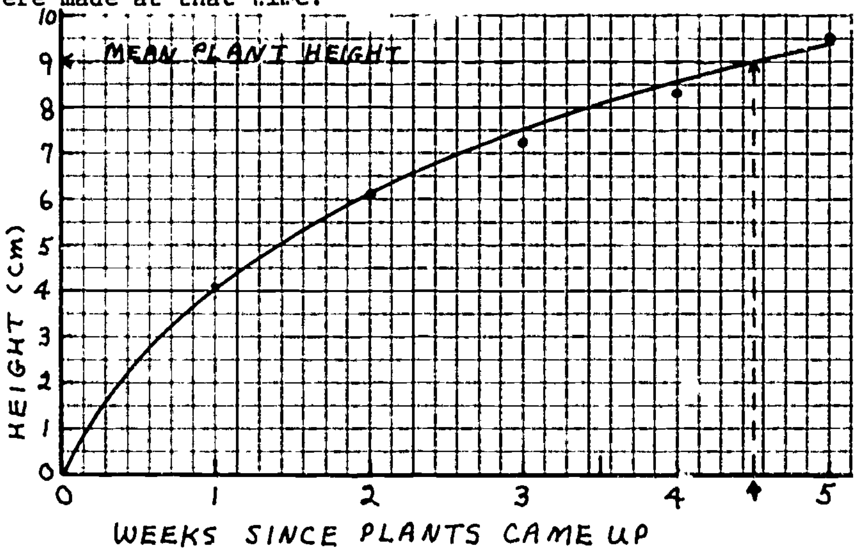
DAYS SINCE PLANTS CAME UP	MEAN HEIGHT (cm)	
	Plants grown in sunlight	Plants grown in dim light
0	0	0
7	5.1	3.6
12	5.7	3.7
16	6.8	4.1
21	7.2	4.3



Line Graph

A graph in which a smooth line, or line segments, pass through or near points representing members of a set of data. Because the line represents an infinity of points, the variable on the horizontal axis must be continuous. If the spaces between the markings on the horizontal axis have no meaning, then the graph is not a line graph, but a line chart (see *Line Chart*), even if the data points are connected by lines. For example, mean height of a group of plants each week. The approximate mean height for 4.5 weeks can be found from the graph even no measurements were made at that time.

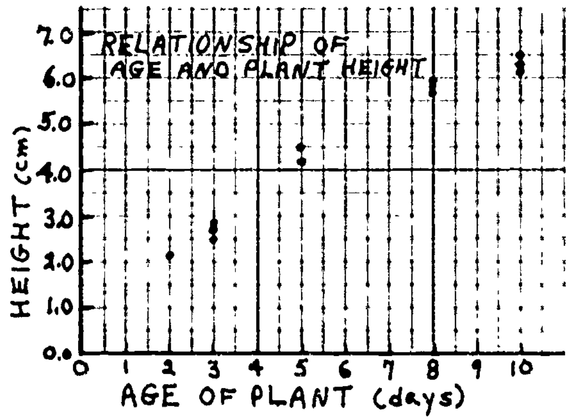
WEEK	MEAN HEIGHT (cm)
0	0
1	4.1
2	6.1
3	7.2
4	8.3
5	9.5



Scatter Graph

A graph showing a scatter of points, each of which represents two characteristics of the same thing. For example, the ages of a group of plants vs. their heights.

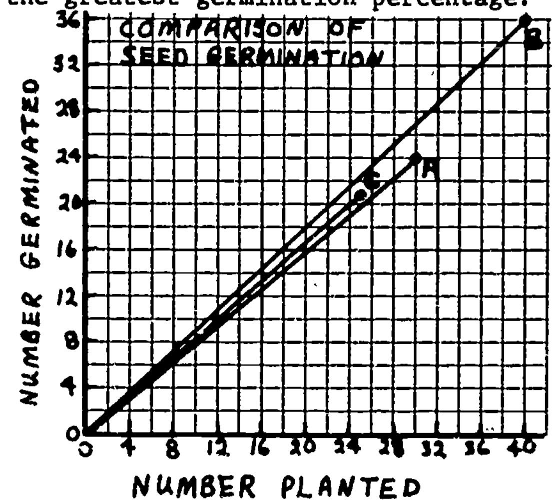
AGE (days)	HEIGHT (cm)
2	2.2
3	2.5
3	2.7
3	2.8
5	4.2
5	4.5
8	5.7
8	5.8
8	5.9
10	6.2
10	6.3
10	6.5



Slope Diagram*

A graphical means of comparing fractions or ratios. To represent the ratio a/b, plot the point (b,a) and draw a line from (b,a) to the origin, (0,0). By comparing the slopes of several lines, different ratios can be compared; the less steep the line the smaller the ratio. For example, the diagram shows the number of seeds that germinated out of the total number planted for several packets of seed. The ratio is larger for packet B than for packets A or C, and, therefore, B has the greatest germination percentage.

PACKET	NUMBER PLANTED	NUMBER GERMINATED
A	30	24
B	40	36
C	25	21



Heredity

The transmission of qualities from one generation to another through genes.

Histogram

See *Graph*.

Hydroponics

The growing of plants in nutrient solutions without the support of a soil medium.

Hypothesis

A tentative proposition or assumption made in order to draw out and test its implication or consequences.

Inference

A conclusion or deduction derived from facts or information considered to be valid and accurate.

Life Cycle

The series of stages through which an organism passes during its life.

Mean

The numerical value obtained by dividing the sum of the numbers of a set of data by the number of members of that set. Also called the *Average*.

*Formerly called triangle diagram.

Median	The middle value in a set of data in which the values have been ordered from smallest to largest. The median value, then, has as many values above it as below it.
Mode	The element or elements in a set of data which occur most often.
Mold	The woolly growth on damp organic matter or soil, which is a type of plant reproducing by spores.
Monocot (Monocotyledon)	A plant which belongs to a large group of flowering plants putting out one cotyledon, or seed leaf, when it first sprouts, e.g., corn.
Nutrient	A chemical substance (found in food or soil) necessary to an organism for life and growth.
Ordered Set	A set of data whose pieces or members have been arranged from smallest to largest.
Organic	The term used to describe something that is or was part of a living plant or animal, e.g., organic fertilizer.
Organism	A living thing, plant or animal.
Per Cent	A numeral which has the form of a fraction with a denominator of 100, e.g., 72/100, 72 per cent or 72 per hundred. The symbol % is considered to represent 1/100. Thus 72:100 = 72 per cent = 72%.
Percentage	A part of a whole which is expressed in hundredths.
Perlite	Round beads of volcanic glass which are water absorbent; useful as a rooting medium or as a plant-growing medium when mixed with soil.
pH	The number value on a scale from 0-14 which reflects the concentration of hydrogen ions in a substance. An <u>acidic</u> substance contains a large proportion of hydrogen ions and registers a low pH (below 7), e.g., vinegar, while a basic or alkaline substance has a low concentration of hydrogen ions and a high pH (above 7), e.g., baking soda. A substance with a pH of 7 is neutral, e.g., salt.
Photosynthesis	The process by which green plants use light as energy to make food from water and carbon dioxide.

Phototropic	A term used to describe the natural tendency of a plant to grow towards a light source.
Pollination	The process by which pollen is transferred from male to female flower parts to form seeds necessary for reproduction.
Probability	The mathematical determination of the likelihood of one event occurring out of several possible events.
Propagation	Reproduction of an organism by one of many ways, e.g., through stem or leaf cuttings from a larger plant or through germination of a seed.
Proportion	A statement of the equivalence of two ratios. When two quantities are related by direct proportion, they have a constant ratio.
Quartile	
First	The first quartile is the value of the quarter-way piece of data in an ordered set of data.
Third	The third quartile is the value of the three-quarter-way piece of data in an ordered set of data.
Interquartile Range	The range, or spread, of the middle 50% of an ordered set of data.
Range	The difference between the smallest and the largest values in a set of data.
Rank	To determine the relative position of pieces of data.
Ratio	A mathematical expression of the relation between two values, e.g., number of seeds which germinate to the total planted.
Sample Set	A representative part or fraction of a larger whole or population studied to gain information about the larger while.
Sample Set Size	The number of pieces of data collected in one sample.
Scale	A direct proportion between two sets of dimensions (as between the dimensions of a plan and the actual construction).

Scale Drawing	A drawing whose dimensions are in direct proportion to the subject drawn.
Seed	A product of pollination of a plant which contains the embryo of a new plant.
Species	A category of scientific classification meaning a group of organisms which look alike and can interbreed.
Spore	A tiny product of some types of plants which can produce another plant either directly or after combining with another spore.
Statistics	The science of drawing conclusions or making predictions (framed in terms of probability) using a collection of quantitative data.
Tally	A record of the number of times one or more events occur.
Terrarium	A container filled with earth or sand in which animals and/or plants are kept indoors.
Slope Diagram	See *Graph*.
Vermiculite	A material made from mica which is highly water absorbent; useful as a rooting medium or as a plant-growing medium when mixed with soil.

E. Skills, Processes, and Areas of Study Utilized in Growing Plants

The unique aspect of USMES is the degree to which it provides experience in the process of solving real problems. Many would agree that this aspect of learning is so important as to deserve a regular place in the school program even if it means decreasing to some extent the time spent in other important areas. Fortunately, real problem solving is also an effective way of learning many of the skills, processes, and concepts in a wide range of school subjects.

On the following pages are five charts and an extensive, illustrative list of skills, processes, and areas of study that are utilized in USMES. The charts rate Growing Plants according to its potential for learning in various categories of each of five subject areas--real problem solving, mathematics, science, social science, and language arts. The rating system is based on the amount that each skill, process, or area of study within the subject areas is used--extensive (1), moderate (2), some (3), little or no use (-). (The USMES Guide contains a chart that rates all USMES units in a similar way.)

The chart for real problem solving presents the many aspects of the problem-solving process that students generally use while working on an USMES challenge. A number of the steps in the process are used many times and in different orders, and many of the steps can be performed concurrently by separate groups of students. Each aspect listed in the chart applies not only to the major problem stated in the unit challenge but also to many of the tasks each small group undertakes while working on a solution to the major problem. Consequently, USMES students gain extensive experience with the problem-solving process.

The charts for mathematics, science, social science, and language arts identify the specific skills, processes, and areas of study that may be learned by students as they respond to a Growing Plants challenge and become involved with certain activities. Because the students initiate the activities, it is impossible to state unequivocally which activities will take place. It is possible, however, to document activities that have taken place in USMES classes and identify those skills and processes that have been used by the students.

Knowing in advance which skills and processes are likely to be utilized in Growing Plants and knowing the extent that they will be used, teachers can postpone the teaching

of those skills in the traditional manner until later in the year. If the students have not learned them during their USMES activities by that time, they can study them in the usual way. Further, the charts enable a teacher to integrate USMES more readily with other areas of classroom work. For example, teachers may teach fractions during math period when fractions are also being learned and utilized in the students' USMES activities. Teachers who have used USMES for several successive years have found that students are more motivated to learn basic skills when they have determined a need for them in their USMES activities. During an USMES session the teacher may allow the students to learn the skills entirely on their own or from other students, or the teacher may conduct a skill session as the need for a particular skill arises.

Because different USMES units have differing emphases on the various aspects of problem solving and varying amounts of possible work in the various subject areas, teachers each year might select several possible challenges, based on their students' previous work in USMES, for their class to consider. This choice should provide students with as extensive a range of problems and as wide a variety of skills, processes, and areas of study as possible during their years in school. The charts and lists on the following pages can also help teachers with this type of planning.

Some USMES teachers have used a chart similar to the one given here for real problem solving as a record-keeping tool, noting each child's exposure to the various aspects of the process. Such a chart might be kept current by succeeding teachers and passed on as part of a student's permanent record. Each year some attempt could be made to vary a student's learning not only by introducing different types of challenges but also by altering the specific activities in which each student takes part. For example, children who have done mostly construction work in one unit may be encouraged to take part in the data collection and data analysis in their next unit.

Following the rating charts are the lists of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in Growing Plants. Like the charts, these lists are based on documentation of activities that have taken place in USMES classes. The greater detail of the lists allows teachers to see exactly how the various basic skills, processes, and areas of study listed in the charts may arise in Growing Plants.

The number of examples in the real problem solving list have been limited because the list itself would be unreasonably long if all the examples were listed for some of the categories. It should also be noted that the example(s) in the first category--*Identifying and Defining Problems*--have been limited to the major problem that is the focus of the unit. During the course of their work, the students will encounter and solve many other, secondary problems, such as the problem of how to display their data or how to draw a scale layout.

Breaking down an interdisciplinary curriculum like USMES into its various subject area components is a difficult and highly inexact procedure. Within USMES the various subject areas overlap significantly, and any subdivision must be to some extent arbitrary. For example, where does measuring as a mathematical skill end and measurement as science and social science process begin? How does one distinguish between the processes of real problem solving, of science, and of social science? Even within one subject area, the problem still remains--what is the difference between graphing as a skill and graphing as an area of study? This problem has been partially solved by judicious choice of examples and extensive cross-referencing.

Because of this overlap of subject areas, there are clearly other outlines that are equally valid. The scheme presented here was developed with much care and thought by members of the USMES staff with help from others knowledgeable in the fields of mathematics, science, social science, and language arts. It represents one method of examining comprehensively the scope of USMES and in no way denies the existence of other methods.

REAL PROBLEM SOLVING	Overall Rating
Identifying and defining problem.	1
Deciding on information and investigations needed.	1
Determining what needs to be done first, setting priorities.	1
Deciding on best ways to obtain information needed.	1
Working cooperatively in groups on tasks.	1
Making decisions as needed.	1
Utilizing and appreciating basic skills and processes.	1
Carrying out data collection procedures--observing, surveying, researching, measuring, classifying, experimenting, constructing.	1
Asking questions, inferring.	1
Distinguishing fact from opinion, relevant from irrelevant data, reliable from unreliable sources.	1

REAL PROBLEM SOLVING	Overall Rating
Evaluating procedures used for data collection and analysis. Detecting flaws in process or errors in data.	1
Organizing and processing data or information.	1
Analyzing and interpreting data or information.	1
Predicting, formulating hypotheses, suggesting possible solutions based on data collected.	1
Evaluating proposed solutions in terms of practicality, social values, efficacy, aesthetic values.	1
Trying out various solutions and evaluating the results, testing hypotheses.	
Communicating and displaying data or information.	1
Working to implement solution(s) chosen by the class.	1
Making generalizations that might hold true under similar circumstances; applying problem-solving process to other real problems.	1

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use.

MATHEMATICS	Overall Rating
Basic Skills	
Classifying/Categorizing	1
Counting	1
Computation Using Operations	
Addition/Subtraction	1
Multiplication/Division	1
Fractions/Ratios/Percentages	1
Business and Consumer Mathematics/ Money and Finance	1
Measuring	1
Comparing	1
Estimating/Approximating/Rounding Off	1
Organizing Data	1
Statistical Analysis	1
Opinion Surveys/Sampling Techniques	2
Graphing	1
Spatial Visualization/Geometry	-
Areas of Study	
Numeration Systems	1
Number Systems and Properties	1
Denominate Numbers/Dimensions	1
Scaling	-
Symmetry/Similarity/Congruence	-
Accuracy/Measurement Error/ Estimation/Approximation	1
Statistics/Random Processes/Probability	1
Graphing/Functions	1
Fraction/Ratio	1
Maximum and Minimum Values	3
Equivalence/Inequality/Equations	2
Money/Finance	1
Set Theory	2

SCIENCE	Overall Rating
Processes	
Observing/Describing	1
Classifying	1
Identifying Variables	1
Defining Variables Operationally	1
Manipulating, Controlling Variables/ Experimenting	1
Designing and Constructing Measuring Devices and Equipment	2
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	1
Measuring/Collecting, Recording Data	1
Organizing, Processing Data	1
Analyzing, Interpreting Data	1
Communicating, Displaying Data	1
Generalizing/Applying Process to New Problems	1
Areas of Study	
Measurement	1
Motion	-
Force	-
Mechanical Work and Energy	-
Solids, Liquids, and Gases	3
Electricity	-
Heat	2
Light	1
Sound	-
Animal and Plant Classification	1
Ecology/Environment	1
Nutrition/Growth	1
Genetics/Heredity/Propagation	1
Animal and Plant Behavior	1
Anatomy/Physiology	2

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

SOCIAL SCIENCE	Overall Rating
Process	
Observing/Describing/Classifying	3
Identifying Problems, Variables	1
Manipulating, Controlling Variables/ Experimenting	3
Inferring/Predicting/Formulating, Testing Hypotheses	3
Collecting, Recording Data/Measuring	-
Organizing, Processing Data	-
Analyzing, Interpreting Data	-
Communicating, Displaying Data	-
Generalizing/Applying Process to Daily Life	3
Attitudes/Values	
Accepting responsibility for actions and results	1
Developing interest and involvement in human affairs	1
Recognizing the importance of individual and group contributions to society	1
Developing inquisitiveness, self-reliance, and initiative	1
Recognizing the values of cooperation, group work, and division of labor	1
Understanding modes of inquiry used in the sciences, appreciating their power and precision	1
Respecting the views, thoughts, and feelings of others	1
Being open to new ideas and information	1
Learning the importance and influence of values in decision making	1
Areas of Study	
Anthropology	-
Economics	3
Geography/Physical Environment	3
Political Science/Government Systems	-
Recent Local History	-
Social Psychology/Individual and Group Behavior	-
Sociology/Social Systems	-

LANGUAGE ARTS	Overall Rating
Basic Skills	
Reading	
Literal Comprehension: Decoding Words Sentences, Paragraphs	1
Critical Reading: Comprehending Meanings, Interpretation	1
Oral Language	
Speaking	1
Listening	1
Memorizing	-
Written Language	
Spelling	2
Grammar: Punctuation, Syntax, Usage	2
Composition	2
Study Skills	
Outlining/Organizing	2
Using References and Resources	1
Attitudes/Values	
Appreciating the value of expressing ideas through speaking and writing	1
Appreciating the value of written resources	1
Developing an interest in reading and writing	1
Making judgments concerning what is read	1
Appreciating the value of different forms of writing, different forms of communication	1

KEY: 1 = extensive use, 2 = moderate use,
3 = some use, - = little or no use

REAL PROBLEM SOLVING IN GROWING PLANTS

Identifying and Defining Problems	• Students decide to grow vegetable and flowering plants to sell at the spring school fair. • Students decide to grow only those plants that grow quickly in the classroom environment. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables*.
Deciding on Information and Investigations Needed	• Students decide to collect data on student, teacher, and parent preferences for plants they would buy. • Students decide they will need information on general needs of plants. • Students decide they will need information on various aspects of growing plants--e.g., germination, transplanting, soils, plant food, light, heat.
Determining What Needs to Be Done First, Setting Priorities	• Students decide to conduct preference survey before buying seeds. • Students decide to research needs of various plants before planting their seeds. • Students determine cost of each plant before setting a selling price.
Deciding on Best Ways to Obtain Information Needed	• Students conduct survey to determine student, teacher, and parent preferences for plants. • Students use library to research information on plants and plant needs. • Students utilize resource persons--e.g., botanist, gardener, biology teacher, agricultural agent--to obtain information on plants and plant needs. • Students determine unit costs for plants by adding cost of seeds, pots, plant food, potting soils, etc., for each type of plant and dividing by the number of plants of each type.
Working Cooperatively in Groups on Tasks	• Students form groups to survey other students, parents, and teachers on their preferences for plants to buy. • Students form new groups to grow specific plants. • Students form groups to arrange and schedule their plant sale.

Making Decisions as Needed

- Students decide which plants to grow on the basis of survey results and plant growth rates and needs.
- Students decide to purchase seeds on bases of quality and lowest cost.
- Students decide to use plant food to help their plants grow better.
- Students decide on selling price for their plants.

Utilizing and Appreciating Basic Skills and Processes

- Students measure plants to determine amount of growth.
- Students measure plant food before giving it to plants.
- Students graph mean plant heights to visualize growth rates.
- Students accept responsibility for scheduling watering and feeding of plants.
- Students research plant needs.
- Students write letters to resource persons to obtain information.
- See also MATHEMATICS, SCIENCE, SOCIAL SCIENCE, AND LANGUAGE ARTS lists.

Carrying Out Data Collection Procedures--Opinion Surveying, Researching, Measuring, Classifying, Experimenting, Constructing

- Students survey others to determine preferences for plants.
- Children research needs and characteristics of various plants.
- Students measure amount of plant food to add to plants.
- Children classify plants in several ways--e.g., monocot vs. dicot, flowering vs. nonflowering.
- Students grow some plants using different amounts of light or plant food.
- Students construct boxes in which to grow plants.
- See also MATHEMATICS list: *Classifying/Categorizing; Measuring.*
- See also SCIENCE list: *Observing/Describing; Classifying; Manipulating, Controlling Variables/Experimenting; Designing and Constructing Measuring Devices and Equipment; Measuring/Collecting, Recording Data.*
- See also SOCIAL SCIENCE list: *Observing/Describing/ Classifying; Manipulating, Controlling Variables/ Experimenting; Collecting, Recording Data/Measuring.*

Asking Questions, Inferring

- Students ask what plants they should grow and infer an answer from survey data on plant preferences of others and from needs and characteristics of various plants.
- Students ask whether plant food will help plants grow better and infer from experimental data that it does.

Asking Questions, Inferring (cont.)

- Students infer from plant growth that sunlight is necessary for growth.
- See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.*
- See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*

Distinguishing Fact from Opinion, Relevant from Irrelevant Data, Reliable from Unreliable Sources

- Students recognize the qualitative aspect of obtaining data from opinion surveys.
- Students recognize that plant height may not be as relevant as its general health (number of leaves, general condition).
- Students recognize that botanists, agricultural agents, gardeners, and horticulturalists are reliable sources of information on plants and their needs.

- Students discuss preference survey before conducting it to make sure it will elicit desired information.
- Children determine how they will measure plant height, amount of plant food.
- Students determine whether they have changed only one thing at a time, amount of plant food or amount of light, in their experiments.
- Students eyeball data on plant height to detect errors in measuring.
- See also MATHEMATICS list: *Estimating/Approximating/Rounding Off.*

Organizing and Processing Data

- Students make charts for plant care for various types of plant.
- Students find means of sets of plant heights before making a line graph.
- Students put plant height measurements in groups before making histograms.
- See also MATHEMATICS list: *Organizing Data.*
- See also SCIENCE and SOCIAL SCIENCE lists: *Organizing, Processing Data.*

Analyzing and Interpreting Data

- Students interpret graphs of plant growth.
- Students use both the medians and middle ranges of two sets of plant heights to determine whether there is a significant difference between the sets.

Analyzing and Interpreting Data (cont.)	• See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Maximum and Minimum Values*. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data*.
Predicting, Formulating Hypotheses, Suggesting Possible Solutions Based on Data Collected	• Students hypothesize that a group of plants aren't growing well because they need to be repotted; they repot them and find that they grow better. • Students experiment to find out that plants grow better in sunlight and with some plant food added. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling*. • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses*.
Evaluating Proposed Solutions in Terms of Practicality, Social Values, Efficacy, Aesthetic Values	• Students discuss which plants to grow based on survey responses and characteristics and needs of various plants. • Students discuss numbers of each kind of plant to grow so that enough plants of each kind will be ready for the sale, taking into account that some seeds won't germinate or that some plants will die. • Students discuss growing flowers for beautification and vegetable plants for their fruit.
Trying Out Various Solutions and Evaluating the Results, Testing Hypotheses	• Students experiment with different groups of the same kind of plant to determine proper amounts of water, light, plant food needed. • Students try out various schedules for taking care of the plants. • Students grow a mixture of vegetable and flower plants to sell for transplanting. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling*. • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses*.
Communicating and Displaying Data or Information	• Students make a chart showing required care for their various plants. • Students draw line graphs of the growth of their plants. • See also MATHEMATICS list: *Graphing; Scaling*.

Communicating and Displaying Data or Information (cont.)

- See also SCIENCE and SOCIAL SCIENCE lists: *Communicating, Displaying Data*.
- See also LANGUAGE ARTS list.

Working to Implement Solution(s) Chosen by the Class

- Students grow vegetable and flower plants to sell at school fair.

Making Generalizations That Might Hold True Under Similar Circumstances; Applying Problem-Solving Process to Other Real Problems

- Students apply skills and information learned to starting and maintaining their own garden.
- Students grow plants to feed animals in a school zoo.
- See also SCIENCE list: *Generalizing/Applying Process to New Problems*.
- See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life*.

ACTIVITIES IN GROWING PLANTS UTILIZING MATHEMATICS

Basic Skills

Classifying/Categorizing

- Categorizing characteristics of plants, soils, fertilizers, etc.
- Using the concepts and language of sets (subsets, unions, intersections, set notation) for discussing plant classification.
- See also SCIENCE list: *Classifying*.
- See also SOCIAL SCIENCE list: *Observing/Describing/Classifying*.

Counting

- Counting votes on decisions made about growing plants.
- Counting survey data on preferences for plants to buy.
- Counting number of seeds, number of plants, number of milliliters, number of centimeters, etc.
- Counting to read scales on measuring instruments, such as ruler, thermometer.
- Counting by sets to find scale for graph axes.
- Counting to find median or middle range of a set of data.

Computation Using Operations: Addition/Subtraction

- Adding one-, two-, or three-digit whole numbers to find total tally, such as number of seedlings, or total measurement, such as amount of plant growth over several months.
- Subtracting heights of plants to find growth of plants over a certain period of time.
- Subtracting one-, two-, or three-digit numbers to find range for graph axes or to compare sets of data.

Computation Using Operations: Multiplication/Division

- Multiplying whole numbers to find volume of terraria or of plant boxes.
- Multiplying or dividing to find scale for graph axes.
- Multiplying or dividing to convert from meters to feet, Celsius to Fahrenheit or vice versa.
- Dividing to calculate average height, average growth rate.
- Dividing to calculate ratios, fractions, or percentages.

Computation Using Operations: Fractions/Ratios/Percentages

- Using mixed numbers to perform calculations, such as average height of several plants (in inches).
- Changing fractions to higher or lower terms (equivalent fractions) to perform operations such as subtraction of plant heights to find growth.
- Using ratios and fractions to convert from meters to feet, etc.
- Using fractions or decimals in measurement, graphing, or graphic comparisons.
- Using slope diagrams to compare ratios of seeds sprouted to the numbers planted for different types of seeds.
- Calculating growth rate over a certain period of time.
- Calculating percentage of plants that live, percentages of students preferring a particular type of plant, etc.
- Using proportions to increase or decrease ingredients in a soil or fertilizer mixture.

Computation Using Operations: Business and Consumer Mathematics/ Money and Finance

- Investigating costs of seeds, plants, soil, pots, etc., vs. budget restrictions.
- Adding and subtracting dollars and cents to perform cost analysis, to figure profit or loss from a plant sale, to make change when selling plants.
- Multiplying and dividing dollars and cents to calculate and compare costs of various plants or materials or to figure profit or loss on sale of a plant.
- Calculating percentage of profit when selling plants.
- Using comparison when shopping for potting soil, fertilizer, pots, plants, etc.

Measuring

- Using arbitrary units (e.g., children's fingers) to measure depth of plant seeds or height of plants.
- Using different standard units of measure to measure wood for plant boxes or greenhouses.
- Measuring amount of water, amount of plant food.
- Reading rulers, thermometers, or measuring cups accurately.
- See also SCIENCE list: *Measuring/Collecting, Recording Data*.
- See also SOCIAL SCIENCE list: *Collecting, Recording Data/Measuring*.

Comparing	• Using the concept of *greater than* and *less than* in comparing numbers or heights of plants. • Comparing qualitative information, such as people's observations and opinions, gathered from various sources. • Comparing qualitative information gathered on plant growth with quantitative data gathered from measuring plants. • Comparing estimated and actual results of plant measurements. • Making graphic comparisons of ratios, such as plant growth rates or ratio of number of seeds sprouted to the total planted. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data*.
Estimating/Approximating/Rounding Off	• Estimating the number of people who will buy certain types of plants, the number of seeds that will sprout, etc. • Estimating costs of plants and containers, amount of potting soil to buy, etc. • Determining when a measurement is likely to be accurate enough for a particular purpose (e.g., construction of plant boxes). • Rounding off measurements while measuring lengths of wood, heights of plants.
Organizing Data	• Recording data on charts. • Making charts for plant care. • Tallying on bar graphs. • Ordering numbers on a graph axis. • Ordering the steps in a process. • Ordering survey results on plant preferences. • Ordering inches, feet, yards; meters, centimeters; cups, pints, quarts, gallons. • See also SCIENCE and SOCIAL SCIENCE lists: *Organizing, Processing Data*.
Statistical Analysis	• Finding the average plant growth over a certain period. • Finding the median in an ordered set of data on plant heights. • Determining the middle range of data on plant heights. • Using both the medians and middle ranges of two sets of plant heights to determine whether there is a significant difference between the sets.

Statistical Analysis (cont.)

- See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data.*

Opinion Surveys/Sampling Techniques

- Conducting surveys on plant preferences; defining data collection methods and the makeup and size of sample.
- Evaluating survey methodology, administration of survey, size and makeup of samples.
- See also SCIENCE list: *Analyzing, Interpreting Data.*
- See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data.*

Graphing

- Using alternative methods of displaying data on growth rates.
- Making a graph form--dividing axes into parts, deciding on an appropriate scale.
- Representing data on graphs.
  - Bar graph--plotting heights of several plants.
  - Conversion graph--converting degrees Fahrenheit to degrees Celsius, or meters to feet.
  - Histogram--numbers of plants of different heights in a group of like plants.
  - Line chart--plotting average plant growth for different plants under different lighting conditions.
  - Line graph--plotting mean height of a group of plants each week.
  - Scatter graph--age of plants vs. heights.
  - Slope diagram--number of seeds that germinate out of total planted for several kinds of plants.
- See also SCIENCE and SOCIAL SCIENCE lists: *Communicating, Displaying Data.*

Spatial Visualization/Geometry

- Drawing or constructing a layout of a greenhouse or garden.
- Constructing and using geometric figures, e.g., triangles and rectangles in the construction of greenhouses.
- Using geometric concepts to understand and utilize relationships, such as volume of space needed by plant roots, size of greenhouse.
- Using standard mensurational formulas, e.g., Volume = Length x Width x Depth.
- Measuring and constructing greenhouses, plant boxes, or shelves using rulers, compasses, protractors.
- Using spatial arrangements of plants to convey information.

Areas of Study

Numeration Systems	• Using metric system (decimal) in measuring distances. • Using fractions in measuring feet. • Using decimal system in calculating costs of plants, soil, fertilizer, containers, construction materials.
Number Systems and Properties	• See *Computation Using Operations*.
Denominate Numbers/Dimensions	• See *Measuring*.
Scaling	• Finding an appropriate scale (proportion) and drawing a scale layout of a garden or greenhouse.
Symmetry/Similarity/Congruence	• See *Spatial Visualization/Geometry*.
Accuracy/Measurement Error/ Estimation/Approximation	• See *Measuring* and *Estimating/Approximating/Rounding Off*.
Statistics/Random Processes/ Probability	• See *Statistical Analysis*.
Graphing/Functions	• See *Graphing*.
Fraction/Ratio	• See *Computation Using Operations: Fractions/Ratios/ Percentages*.
Maximum and Minimum Values	• Growing those plants that are the most popular for the least cost and care. • Growing those plants that grow best under certain conditions and are the most popular.
Equivalence/Inequality/Equations	• See *Comparing* and *Computation Using Operations*.
Money/Finance	• See *Computation Using Operations: Business and Consumer Mathematics/Money and Finance*.
Set Theory	• See *Classifying/Categorizing*.

ACTIVITIES IN GROWING PLANTS UTILIZING SCIENCE

Process

Observing/Describing	• Observing and describing various things about plants, e.g., physical characteristics, growth needs. • Observing that some plants grow more quickly than others. • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying.*
Classifying	• Classifying plants according to physical characteristics, e.g., monocot vs. dicot, flowering vs. nonflowering. • Categorizing information about plants, e.g., behavior, growth needs, characteristics, that can be presented to others. • See also MATHEMATICS list: *Classifying, Categorizing.* • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying.*
Identifying Variables	• Identifying color of leaves, number of leaves, presence of spots, insects, etc., as things to observe in order to tell if a plant is healthy. • Identifying amount of water, light, space to grow, as variables to be controlled when experimenting with different plant fertilizers. • Identifying type of fertilizer as the variable to be changed when experimenting with food preference. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables.*
Defining Variables Operationally	• Defining amount of light as the amount of sunlight or room light that a plant receives during a day. • Defining types of fertilizer as fertilizers recommended by books and/or plant experts for the particular plant (e.g., compost, fish meal, chemical mix).
Manipulating, Controlling Variables/ Experimenting	• Designing and controlling an experiment to determine which type of fertilizer a certain kind of plant prefers. • Keeping water, growing space, and light the same while experimenting with fertilizer types.

Manipulating, Controlling Variables/ Experimenting (cont.)	• See also SOCIAL SCIENCE list: *Manipulating, Controlling Variables/Experimenting.*
Designing and Constructing Measuring Devices and Equipment	• Designing and constructing shelves for plants, plant boxes, terraria.
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	• Inferring on the basis of an experiment that a certain plant grows best in compost. • Predicting the percentage of seeds that will germinate from the results of a germination test. • Hypothesizing that a plant is sick because it doesn't have enough space to grow; repotting the plant and finding that this is so. • See also SOCIAL SCIENCE list: *Inferring/Predicting/ Formulating, Testing Hypotheses.*
Measuring/Collecting, Recording Data	• Measuring the height of plants several times a week to see how much they have grown; recording heights on a chart. • Collecting data on plants by daily observation. • Researching information on plants and plant care from library books. • Measuring to construct plant boxes or shelves. • See also MATHEMATICS list: *Measuring.* • See also SOCIAL SCIENCE list: *Collecting, Recording Data/Measuring.*
Organizing, Processing Data	• Recording data on charts. • Ordering data on plant heights from smallest to largest. • Putting plant heights into groups before making a histogram. • Finding the median or mean height of plants on different days. • Organizing data from library research, observations, and experiments on plants. • See also MATHEMATICS list: *Organizing Data.* • See also SOCIAL SCIENCE list: *Organizing, Processing Data.*

Analyzing, Interpreting Data	• Calculating mean growth rates of plants from mean height measurements and time interval between measurements. • Determining from growth rates that certain plants grow faster when a certain fertilizer is used. • Determining whether there is a significant difference between two sets of plant heights by using both the medians and middle ranges of the sets. • Calculating percentage of seeds germinated based on the number of seeds sprouting out of total planted. • Determining from observations that some plants grow better in direct sunlight than others. • Determining that the present watering schedule is adequate for plants. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing.* • See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data.*
Communicating, Displaying Data	• Showing data on various types of graphs. • Showing information about plants on displays or in pamphlets for people. • Showing information about a proposed greenhouse or a garden on a layout. • See also MATHEMATICS list: *Graphing.* • See also SOCIAL SCIENCE list: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.
Generalizing/Applying Process to New Problems	• Applying knowledge and skills learned to take care of house plants at home or to start and tend a garden at home. • Applying knowledge learned from working with plants to work on Nature Trails. • See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

Areas of Study

Measurement	• Measuring plant height with different instruments. • Determining how accurate a measurement needs to be. • Measuring dimensions of a proposed garden, lengths of wood for a greenhouse, etc. • Measuring water in liquid measuring containers.

Measurement (cont.)	• Investigating amounts of nutrients in various plant fertilizers. • See also *Designing and Constructing Measuring Devices and Equipment*. • See also MATHEMATICS list: *Measuring*.
Force	• Observing that force must be used to push a handsaw or hammer nails into wood for plant boxes. • Observing that saber saws are faster and require less effort to cut Tri-Wall or lumber than handsaws. • Noting that a wheelbarrow acts as a lever, which multiplies force and enables one to carry a heavy load.
Friction	• Observing that as a piece of wood is sanded it becomes smoother and offers less resistance to the motion of sandpaper. • Observing that a blade becomes warmer when a piece of wood is sawed vigorously, because doing work against the force of friction generates heat.
Mechanical Work and Energy	• Observing that using handsaws requires energy. • Observing that electrical energy is transformed into mechanical energy when power tools are used. • See also *Force*.
Solids, Liquids, and Gases	
States of Matter	• Observing that water vapor given off by plants condenses on the inside of terraria. • Observing that nutrients can be found in both solid and liquid fertilizer substances.
Properties of Matter	• Observing, while using litmus paper to test pH of soil, that some soils are more acidic than others. • Observing that adding fertilizer or compost containing nitrogen, phosphorus, potassium and "trace elements" improves the growth of plants. • Observing that certain types of soil hold more water than others. • Observing that a plant rooting in water is not supported by the medium, while a plant rooting in soil receives support from the medium.

Heat/Temperature

- Observing and measuring changes in temperature by reading thermometers placed in plants' environments to determine how plants grow under various conditions.

Light

- Noting through observations and experiments that plants use light as a source of energy to grow.
- Observing that some plants grown under fluorescent light only will not flower or bear fruit; different light sources give out different kinds of light.

Animal and Plant Classification

- Observing that plants have certain physical characteristics that distinguish them from animals and from other types of plants. A scientific system of classification has been devised for all living things based on physical differences and similarities.

Plant
- Flowering
  - Dicot (marigolds, beans, coleus)
  - Monocot (onions, corn, hyacinth)
- Nonflowering
  - Conifers (pine tree, fir)
  - Ferns
  - Fungi (mushrooms, mold)
  - Algae

Animal

Ecology/Environment

- Noting that the health of a plant depends on its environment, which includes the care it receives: water, light, nutrients, warmth, space.
- Observing that different kinds of plants prefer different amounts of light and water and different kinds of soil.
- Observing that decayed matter in compost or manure helps plants grow; matter is recycled through living things.

Nutrition/Growth

- Observing that green plants need light in order to live and grow; chlorophyll in their leaves and stems traps light energy and converts it along with nutrients into food.
- Observing that different plants grow better with different fertilizer mixtures.
- Observing and recording growth in plants by measuring plant heights regularly.

Genetics/Heredity/Propagation

- Observing that plants may be propogated by germinating seeds or by rooting cuttings.
- Observing that seeds and cuttings produce plants that resemble the plants from which they came.

Animal and Plant Behavior

- Observing that plants placed in a sunny window will often grow towards the light.
- Observing that when a seed germinates the roots will grow downwards and the stem, upwards.
- Observing that plants in gardens follow seasonal growth patterns that are regulated by the length of daylight and the air temperature.

Anatomy/Physiology

- Noting differences in plants based on structure.
- Observing veins in leaves that are used to conduct water and nutrients throughout the plant.

ACTIVITIES IN GROWING PLANTS UTILIZING SOCIAL SCIENCE

Process	
Observing/Describing/Classifying	• Observing and describing effects on students of caring for and learning about plants. • Observing that most people enjoy plants and like growing them. • Categorizing types of information that can be presented to other students. • See also MATHEMATICS list: *Classifying/Categorizing*. • See also SCIENCE list: *Observing/Describing, Classifying*.
Identifying Problems, Variables	• Identifying different attitudes students have towards plants. • Identifying number and type of plants as variables that can be changed to make a room more attractive or a plant sale more profitable. • Identifying plant displays as a factor that can be changed to increase interest in a plant sale or make a room more attractive. • See also SCIENCE list: *Identifying Variables*.
Manipulating, Controlling Variables/ Experimenting	• Conducting preference surveys to find out which types of plants people prefer. • Experimenting with different types of plant displays for a plant sale or an open house. • Trying different ways of sharing care of plants among people in the class. • See also SCIENCE list: *Manipulating, Controlling Variables/Experimenting*.
Inferring/Predicting/Formulating, Testing Hypotheses	• Inferring from results of a preference test that students prefer asparagus ferns, coleus, and Swedish ivy over other house plants. • Inferring that caring for plants make students appreciate them more. • Hypothesizing that a certain type of display will increase interest in a plant sale; testing hypothesis by counting numbers of plants sold when different displays are used.

Inferring/Predicting/Formulating, Testing Hypotheses (cont.)

- Hypothesizing that the results of a preference survey on a sample of students reflect the opinions of all students.
- Testing hypothesis by conducting a second sample survey.
- See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*

Collecting, Recording Data/Measuring

- Using voting procedure to solve problems and make choices.
- Administering an opinion survey on preferences for types of plants.
- Counting number of plant sales or number of visitors to an open house.
- See also MATHEMATICS list: *Counting/Measuring.*
- See also SCIENCE list: *Measuring/Collecting, Recording Data.*

Organizing, Processing Data

- Tallying votes to determine ways of solving a problem.
- Tallying questionnaire data on plant preferences.
- Tallying number of plant sales, number of visitors to an open house.
- See also MATHEMATICS list: *Organizing Data.*
- See also SCIENCE list: *Organizing, Processing Data.*

Analyzing, Interpreting Data

- Comparing qualitative information gathered from interviews with different people.
- Making a decision based on results of a class vote.
- Determining which plants are most popular from results of a preference survey.
- Evaluating survey methodology, size and makeup of sample.
- Determining which plant display made a plant sale more profitable or a room more attractive for an open house.
- See also SCIENCE list: *Analyzing, Interpreting Data.*

Communicating, Displaying Data

- Representing data from preference surveys on graphs or charts.
- Making charts or graphs of number of plants sold, number of visitors to an open house.
- See also MATHEMATICS list: *Graphing.*
- See also SCIENCE list: *Communicating, Displaying Data.*
- See also LANGUAGE ARTS list.

Generalizing/Applying Process to Daily Life	• Using knowledge acquired from teaching students about plants to teach people about other things. • Using knowledge acquired from taking opinion surveys on plant preferences to help solve other problems where attitudes are important. • Using knowledge acquired about plants to increase appreciation of selves and others towards plants. • See also SCIENCE list: *Generalizing/Applying Process to New Problems*.

Attitudes/Values

Accepting Responsibility for Actions and Results	• Making sure that various tasks (e.g., watering plants, making plant boxes) are done. • Scheduling times for an open house or plant sale.
Developing Interest and Involvement in Human Affairs	• Growing plants for others to enjoy.
Recognizing the Importance of Individual and Group Contributions to Society	• Recognizing that plants benefit not only themselves but others as well (e.g., people who buy them or receive them as gifts). • Recognizing that outdoor gardens enhance the entire community by providing greenery and sometimes food for people.
Developing Inquisitiveness, Self-Reliance, and Initiative	• Conducting small and large group sessions with help from the teacher. • Finding solutions to problems encountered in addition to the main problem of the challenge. • Using the telephone to find information or to get in touch with plant experts. • Choosing and developing the best plant display for an open house or a plant sale. • Developing self-reliance by growing their own vegetables to eat.
Recognizing the Values of Cooperation, Group Work, and Division of Labor	• Finding that work progresses more rapidly and smoothly when done in groups. • Eliminating needless overlap in work. • Finding that work is fun when people cooperate.

Understanding Modes of Inquiry Used in the Sciences; Appreciating Their Power and Precision	• Using scientific modes of inquiry to investigate and solve problems when growing plants. • Using data, graphs, drawings, and written materials to tell others about plants. • See also MATHEMATICS and SCIENCE lists.
Respecting the Views, Thoughts, and Feelings of Others	• Considering all suggestions and assessing their merits. • Considering the opinions of others when growing plants. • Recognizing and respecting differences in values according to age, experience, occupation, income, interests, culture, race, religion, ethnic background. • Respecting the thoughts, interests, and feelings of members of the opposite sex when working in groups.
Being Open to New Ideas and Information	• Considering alternative ways of doing various tasks. • Conducting library research on plant physiology, plant care. • Asking other people for opinions, ideas, and information.
Learning the Importance and Influence of Values in Decision Making	• Recognizing that attitudes towards plants reflect the values of each individual. • Recognizing that plants (and other things) have a value that cannot be computed in moneta'y terms.

Areas of Study

Anthropology	• Observing and describing responses to plants related to cultural and geographic background.
Economics	• Gaining experience in comparative shopping for plants, seeds, pots, and other materials for growing plants. • Gaining experience with taking inventory, record keeping, quantity purchasing and quality control when selling plants to make money.
Geography/Physical Environment	• Investigating differences in plants (e.g., ferns and cacti) due to differences in geography or topography of their original habitats.

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Political Science/Government Systems	• Determining need for rules when caring for plants or working outside in a garden. • Working with school authorities or private land owners when making a garden.
Recent Local History	• Investigating previous attempts to sell plants at school or make a school or community garden.
Social Psychology/Individual and Group Behavior	• Recognizing and using different ways of approaching different groups, such as students and administrators. • Recognizing need for leadership within small and large groups; recognizing different capacities of individuals for various roles within groups. • Analyzing the effect of a small group making decisions for a larger group. • Using a plant display to generate interest in plant sale or open house.
Sociology/Social Systems	• Considering the integral, related nature of the school community when selling plants or making a garden. • Devising a system of working cooperatively in small and large groups. • Investigating problems and making changes that affect not only themselves, but society (other students, parents, older people). • Working within established social systems to grow plants or make a garden. • Experiencing and understanding differences in social systems in different social groups (children, adults, women, men, homemakers). • Recognizing that there are many different social groups and that one person belongs to more than one social group.

ACTIVITIES IN GROWING PLANTS UTILIZING LANGUAGE ARTS

Basic Skills

Reading: Literal Comprehension--Decoding Words, Sentences, and Paragraphs	• Decoding words, sentences, and paragraphs while reading books on plants and care; while reading directions on seed or fertilizer packages.
Reading: Critical Reading--Comprehending Meanings, Interpretation	• Obtaining factual information about plants and their care. • Understanding what is read about plants. • Interpreting what is read, such as botany concepts.
Oral Language: Speaking	• Offering ideas, suggestions, and criticisms during discussions in small group work and class discussions on problems and proposed solutions. • Reporting to class about data collection, research activities, graphing. • Responding to criticisms of activities. • Preparing, practicing, and giving an effective oral presentation to the principal requesting permission to make a garden. • Using the telephone properly and effectively to obtain information or to invite a resource person to speak to the class. • Conducting opinion surveys on plant preferences. • Using rules of grammer in speaking.
Oral Language: Listening	• Conducting interviews of botanists, horticulturalists. • Following spoken instruction. • Listening to group reports.
Oral Language: Spelling	• Using correct spelling in writing reports, booklets on plant care.
Written Language: Grammar	• Using rules of grammar in writing.

Written Language: Composition	• Writing to communicate effectively: • preparing written reports and pamphlets using notes, data, graphs, etc., explaining care of plants. • writing posters for advertising a plant sale. • writing opinion surveys for other children; devising questions to elicit desired information; judging whether a question is relevant and whether its meaning is clear.
Study Skills: Outlining/Organizing	• Taking notes when consulting authorities or books about plants, gardens, etc. • Developing opinion survey; ordering questions around the central theme of preferences for types of plants. • Planning presentations, experiments, etc. • Planning and preparing drafts of pamphlets, reports for critical review by the class. • Organizing ideas, facts, data for inclusion in pamphlets, reports, presentations, etc.
Study Skills: Using References and Resources	• Using the library to research information on plants. • Using dictionary and encyclopedia to locate information. • Using indexes and tables of contents of books to locate desired information. • Inviting an expert on botany or horticulture to speak to the class and answer questions. • Using "How To" Series and other booklets for information on graphing, making an opinion survey, etc.
Attitudes/Values	
Appreciating the Value of Expressing Ideas Through Speaking and Writing	• Finding that classmates and teacher may approve of an idea if it is presented clearly. • Finding that other students may appreciate plants or a garden if they are explained clearly and with enthusiasm.
Appreciating the Value of Written Resources	• Finding that certain desired information can be found in books on plants, e.g., regular care, what to do about disease and pests, etc.

Developing an Interest in Reading and Writing	• Willingly looking up information on plants and plant care. • Looking up further or more detailed information. • Showing desire to work on drafting pamphlets, surveys.
Making Judgments Concerning What is Read	• Deciding whether what is read is applicable to the particular problem. • Deciding how reliable the information obtained from reading is. • Deciding whether the written material is appropriate, whether it says what it is supposed to say, whether it may need improvement.
Appreciating the Value of Different Forms of Writing, Different Forms of Communication	• Finding that how information can be best conveyed is determined in part by the audience to whom it is directed. • Finding that certain data or information can be best conveyed by writing it down, making sketches, drawing graphs or charts, etc. • Finding that information on plants and care can be most easily shared by speaking. • Finding that certain data or information should be written down so that it can be referred to at a later time. • Finding that spoken instructions are sometimes better than written instructions, and vice versa.